トルコ共和国

トルコ環境都市計画省、イスタンブール県

トルコ共和国
耐震補強技術普及促進事業
業務完了報告書

2020 年 2 月

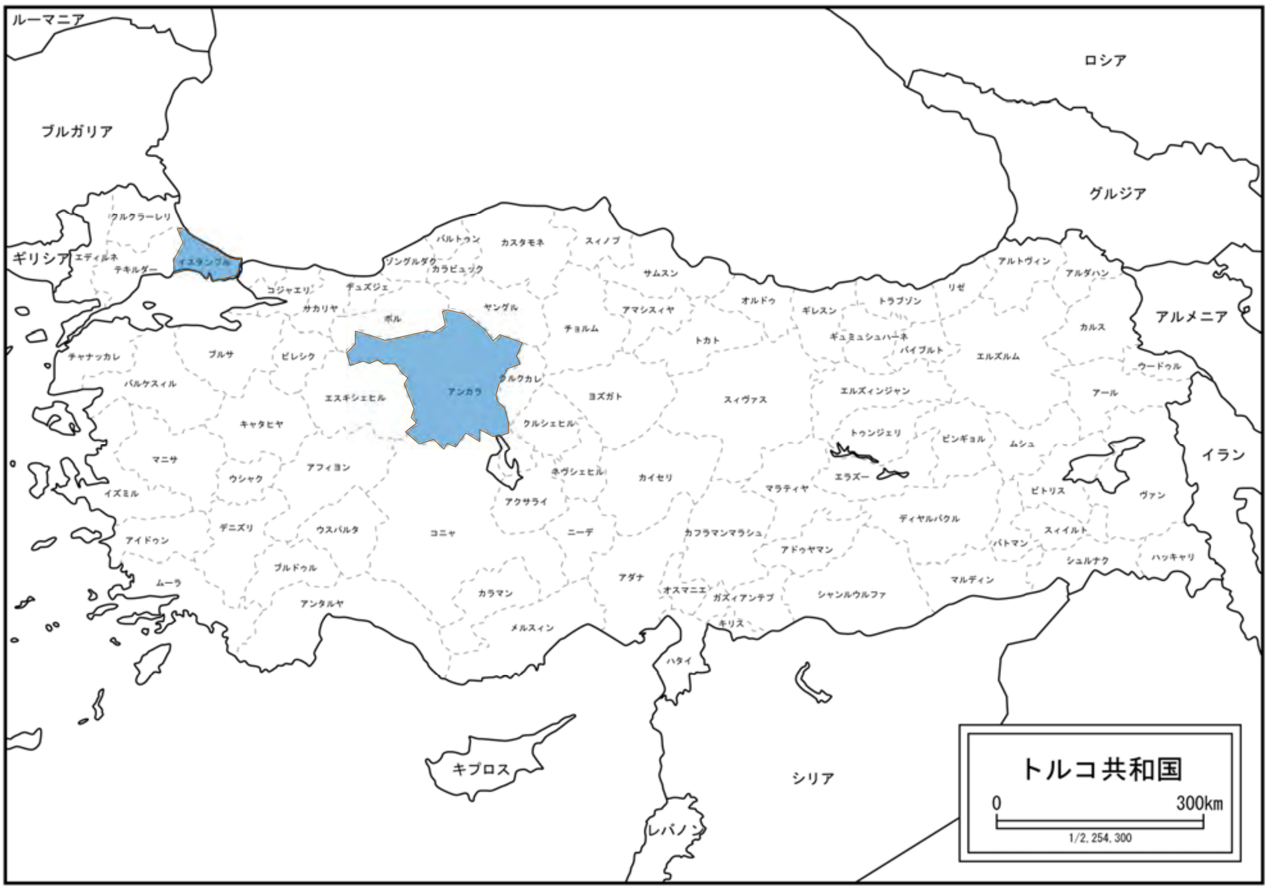
独立行政法人
国際協力機構（JICA）

前田建設工業株式会社

民連
JR
20-029

目次

地図



地図 - トルコ共和国（提案法人作成）

：主な活動場所となったイスタンブール県およびアンカラ県

略語表 （提案法人作成）

略語	正式名称	日本語名称
MF	MaSTER FRAME	マスターフレーム
IPKB	Istanbul Project Coordination Unit	イスタンブールプロジェクトコーディネーションユニット
ISMEP	Istanbul Seismic Risk Mitigation and Emargency Preparedness Project	イスタンブール耐震・防災プログラム
GKMC	GKMC Construction and Consultancy	GKMC 社
ODA	Official Development Assistance	政府開発援助
AFAD	Disaster and Emergency Management Authority	トルコ災害緊急事態管理局
ITU	Istanbul Technical University	イスタンブール工科大学
JICA	Japan International Cooperation Agency	日本国際協力機構
GK	GK Global BV	GK ｸﾞﾛｰﾊﾞﾙ社
MC	Maeda Corporatoin	前田建設工業株式会社
TF	Task Force	タスクフォース
Mpa	Mega pascal	メガパスカル
MoEU	Ministry of Environment and Urbanisation	環境都市計画省
MoNE	Ministry of National Education	国民教育省
MCE	Maximum Considered Earthquake	2500 年周期地震荷重
DBE	Design Base Earthquake：	500 年周期地震荷重
GDP	Gross Domestic Product	国内総生産
Mpa	Mega pascal	メガパスカル

第1章 要約

1.1. 要約

トルコ共和国は国内に多くの断層を有する地震国であり、近年では 1999 年のイズミット地震で大規模な被害を受けた。それ以降、地震対策が喫緊の課題となっている。大都市圏であるイスタンブールでは、特に学校や病院に対して、世界銀行やイスラム開発銀行から融資を受け耐震化工事を鋭意進めている。他方、地方の学校や庁舎・病院など公共施設はトルコ全土に点在しており、それらに対しても迅速な対策実施が求められている。現状では未だ耐震補強もしくは建替えが必要な建物が多く残されている。耐震化が進まない要因としては、調査、工事費用の面の課題が大きいようだが、耐震補強工事を行う際に発生する建物からの一時立ち退きや、一時使用不可能状態等の不便さも影響していると考えられる。

日本で前田建設工業株式会社（以下「前田建設」という）を含む複数の企業、大学により共同開発された耐震補強技術 MaSTER FRAME 構法（以下 MF 構法）は、日本国内で学校、庁舎、住宅、事務所ビルなどの耐震補強で実績を重ねている。MF 構法は、新しく開発されたディスクアンカーを用いた外付け鉄筋コンクリートフレームによる補強で建物の耐震化を図る。MF 構法の特徴は、従来の外付けフレームによる耐震補強工法に比べて低騒音、低振動で施工でき、工事のために建物内部に立ち入る必要はないため建物を供用しながら外部にて工事をする「居ながら施工」が可能なことである。また、既存の建物構造を利用し、窓などの開口部を遮らない設計思想であるため、採光や眺望が悪くなることもない。MF 構法を導入することで、耐震補強工事のために建物の利用を制限することが好ましくない公共施設、学校や病院などの耐震化、また民間の工場、事務所棟などの耐震化推進に貢献できると考えている。

MF 構法はトルコでは実用化されていない新しい耐震補強技術であるため、建築基準や耐震基準への適合性など、採用の大前提となる法規上の課題がある。よって本事業ではタスクフォースを立ち上げ、環境都市計画省等と共に技術検証を行った。その際、トルコのイスタンブール工科大学の准教授に座長を務めていただき、その他設計事務所らと協力して MF 構法の構造モデリング・解析を行い、トルコ共和国の建物への MF 構法の適合性を証明し、技術検証を行った結果をタスクフォース報告書としてまとめ挙げた。これをもって、関係機関に広く MF 構法が耐震補強に有用な技術であることを認識してもらう材料として活用できるようになった。

MF 構法での耐震補強工事を行った実績を、実際に目で見て肌で感じることで技術に対する信頼が生まれると考え、本邦受入れ活動を実施した。本邦受入れ活動では計 6 名（環境都市計画省 4 名、国民教育省 1 名、イスタンブール・プロジェクトコーディネーションユニット（IPKB：ISMEP 実行機関）1 名）の受入れとなった。活動では日本の仙台市で実際に行った工事実績の見学、前田建設の技術研究所の視察およびディスクアンカーのメーカーであるサンコーテクノ株式会社の研究所でアンカー設置のデモ施工を実施して、比較的低振動、低騒音であることを体験していただいた。4 泊 3 日のあわただしい工程であったが、実際の構造物、施工を目にしたことにより安心感を得て、最先端の技術研究所を視察することで前田建設への信頼も生まれたのを強く感じた。MF 構法が信頼できる技術であることが認められた後、対象機関であるイスタンブール県もしくは環境都市計画省に実際に耐震補強を行う建物を選定してもらい、パイロットプロジェクトを実施する計画であった。理解を深めていただいた甲斐があって、この度はイスタンブール県の耐震補強プログラム（ISMEP）の中から選定された建物に対して MF 構法による設計を、ISMEP の設計業務請負会社である設計事務所と行い、内容を確認の上設計図書一式を共有することができた。設計事務所は一式で請負っている設計業務を全てまとめたのち、本パイロットプロジェクト用の設計と合わせて実施機関へ提出することになる（2020 年 1 月見込み）。今後、発注者による施工のための資金調達、入札を経て工事着手、竣工することを強く希望している。

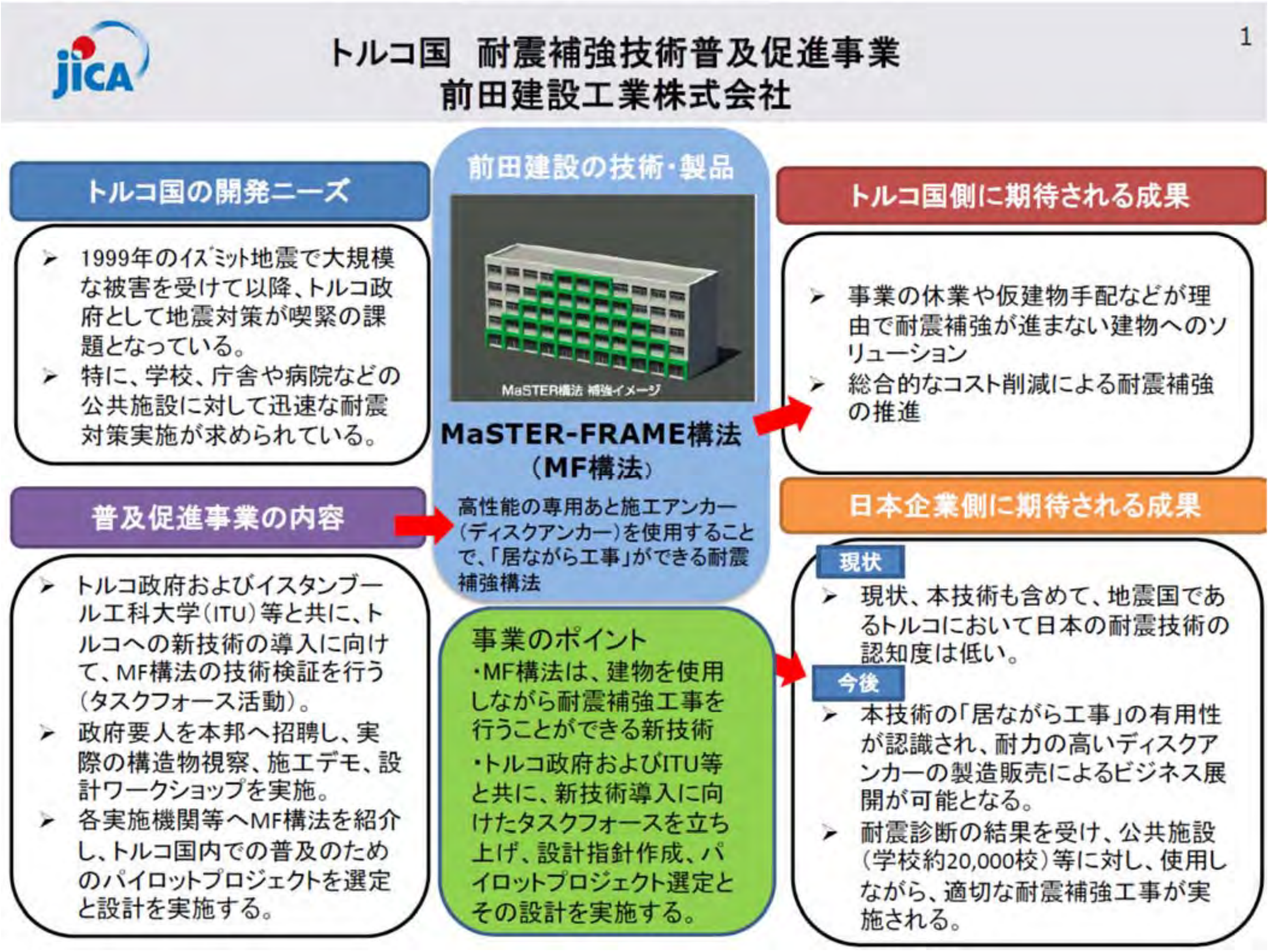
そのほかには、MF 構法の設計・施工指針の作成が主な活動として行われた。日本とトルコでは耐震基準が異なるため日本の基準に合わせて作成されていた設計方法はトルコの基準に適合する形で作り直さなくてはならなかった。トルコの耐震基準は本事業契約期間中の 2019 年 1 月に改訂されたため、この新基準に適合する形での設計指針作成をすすめた。イスタンブール工科大学の構造解析の専門家である准教授に主導していただき、設計指針の初版が完成した。施工手順については日本もトルコも大差ないことから、日本語版を翻訳し、必要な訂正を加える形で完成した。

本事業を通じたビジネス展開は MF 構法の必要治具であるディスクアンカーを GKMC Construction and Consultancy 社（GKMC 社、前田建設とトルコの GK ｸﾞﾛｰﾊﾞﾙ社（GK 社）で設立した合弁会社）が製造販売することで得る事業収益である。トルコで現地生産することで価格競争力を発揮し調達を容易にする。複数のメーカーと交渉中だが製造予定数量が未定であり、かつ今後の展開にも目処が立たないことなどから交渉は難航している。今後ビジネス展開していくにあたって工業規格の取得も必要であり手続きを進めている。前例のない仕様であるため、こちらも手続きが難航しており、予定を大幅に遅れているが、現地生産体制は 2020 年 01 月、工業規格取得は 2020 年 03 月頃に完了する見込みである。

耐震補強が必要な公共の建物で数が多く重要性が高いものとして学校がある。公開された詳しい情報はないが、建物の建築時期等を考慮すると現時点でも多数の公立学校が、耐震補強が必要な状態と推定される。公立学校を所管しているのは国民教育省であるが、以前同省は新しい耐震補強技術の採用には前向きではなく、本事業の対象機関としては選定しなかった経緯がある。しかしながら、本邦受入れ活動に参加していただいた国民教育省の建設不動産局局長は大変興味と理解を示してくれており、今後、MF 構法が必要であり適切と思われる環境下で採用され、耐震補強が行われる可能性は広がっている。

耐震補強を実施している、または実施する役割を担っているトルコの政府機関が口をそろえて言うのは、耐震化のための予算の確保ができず、耐震化が進まないという事であった。建物の耐震化には、MF 構法の様に既存の建物を補強する方法と、古い建物を取り壊し、新しく作り直す方法がある。当然新設の方が費用は多くかかるため、数を多くこなすことができない。また大地震が起れば、甚大な被害が発生する可能性は否定できない現状である。よってその前に、できるだけ多くの建物を耐震補強し、被害を軽減する事は一つの防災対策として肝要である。日本と同じように地震災害の脅威に晒されているトルコとの防災協力が ODA 事業と連携して進んでいくことで資金面での問題も乗り越えていけるのではないかと考えている。

1.2. 事業概要図



1
トルコ国 耐震補強技術普及促進事業
前田建設工業株式会社
トルコ国の開発ニーズ
➢ 1999年のイズミット地震で大規模な被害を受けて以降、トルコ政府として地震対策が喫緊の課題となっている。
➢ 特に、学校、庁舎や病院などの公共施設に対して迅速な耐震対策実施が求められている。
前田建設の技術・製品
MaSTER構法 補強イメージ
MaSTER-FRAME構法（MF構法）
高性能の専用あと施工アンカー（ディスクアンカー）を使用することで、「居ながら工事」ができる耐震補強構法
トルコ国側に期待される成果
➢ 事業の休業や仮建物手配などが理由で耐震補強が進まない建物へのソリューション
➢ 総合的なコスト削減による耐震補強の推進
普及促進事業の内容
➢ トルコ政府およびイスタンブール工科大学（ITU）等と共に、トルコへの新技術の導入に向けて、MF構法の技術検証を行う（タスクフォース活動）。
➢ 政府要人を本邦へ招聘し、実際の構造物視察、施工デモ、設計ワークショップを実施。
➢ 各実施機関等へMF構法を紹介し、トルコ国内での普及のためのパイロットプロジェクトを選定と設計を実施する。
事業のポイント
・MF構法は、建物を使用しながら耐震補強工事を行うことができる新技術
・トルコ政府およびITU等と共に、新技術導入に向けたタスクフォースを立ち上げ、設計指針作成、パイロットプロジェクト選定とその設計を実施する。
日本企業側に期待される成果
現状
➢ 現状、本技術も含めて、地震国であるトルコにおいて日本の耐震技術の認知度は低い。
今後
➢ 本技術の「居ながら工事」の有用性が認識され、耐力の高いディスクアンカーの製造販売によるビジネス展開が可能となる。
➢ 耐震診断の結果を受け、公共施設（学校約20,000校）等に対し、使用しながら、適切な耐震補強工事が実施される。

第2章 本事業の背景

2.1. 本事業の背景

トルコ共和国、通称トルコは、西アジアに位置するアナトリア半島（小アジア）と東ヨーロッパに位置するバルカン半島東端の東トラキア地方を領有する共和制国家。首都はアナトリア中央部のアンカラ。アジアとヨーロッパの 2 つの大州にまたがる。北は黒海、南は地中海に面し、西でブルガリア、ギリシャと、東でジョージア（グルジア）、アルメニア、アゼルバイジャン、イラン、イラク、シリアと接する。

トルコは三権分立を標榜しており、立法府として一院制のトルコ大国民議会（Türkiye Büyük Millet Meclisi 定数 550 名、任期 5 年）、行政府として大統領および内閣、司法府として最高裁判所 (Yargıtay) が置かれる。国権の最高機関はトルコ大国民議会で、一院制により強い権限をもつ。国家元首は国民投票によって選出される大統領（任期 5 年）が務めるが、行政は議会の承認に基づき大統領が間接的に指名する首相の権限が強い議院内閣制をとる。2017 年の憲法改正によって、大統領権限の強化と議院内閣制の廃止が予定されている。この政治制度を規定する現行の憲法は 1980 年のクーデターの後、1982 年に定められ、2007 年、2010 年の改正を経た後、2017 年にも改正案が国民投票で承認された。2018 年から、首相職を廃止し大統領に権限が 集中する大統領制に移行した。

トルコの産業は近代化が進められた工業・商業と、伝統的な農業とからなり、農業人口が国民のおよそ 40%を占める。もっぱら軽工業が中心で、繊維・衣類分野の輸出大国である。経済部門における財閥の力が大きく、近年では世界の大手自動車メーカーと国内の大手財閥との合弁事業を柱として重工業の開発が進められている。ただし、工業化が進んでいるのは北西部のマルマラ海沿岸地域がほとんどで、観光収入の多い地中海・エーゲ海沿岸地域と、首都アンカラ周辺の大都市圏以外では、経済に占める農業の比重が大きい。とくに東部では、地主制がよく温存されているなど経済近代化の立ち遅れが目立ち、農村部の貧困や地域間の経済格差が大きな問題となっており、数十年にわたる政府の開発推進政策によっても解消をみていない。

トルコ共和国は日本国と同様に国内に多くの断層を有する地震国であり、近年では 1999 年のイズミット地震で大規模な被害を受けている。以降、トルコ政府としは地震対策が喫緊の課題となっている。特に学校や病院などについては、イスタンブールなど大都市部では世界銀行のファイナンスを活用した耐震化工事が鋭意進められている実態があるものの、地方の学校や庁舎・病院など公共施設はトルコ全土に点在しており、耐震化のための具体的な計画はない。それらに対しても迅速な対策実施が求められている。

耐震化の計画は各省庁において策定されているようだが、その予算措置を含めて具体的にどのようなスピード／スケジュールで進められていくのかについては公開情報が少なく把握が難しい。

トルコ面積の 66%、人口の 71%、製造施設 （生産工場など）の 76%は地震ゾーン 1 及び 2（図-2.1-1、2.1-2 参照：公共事業住宅省により地震の危険度を 5 段階でゾーニングしており、地震に対する設計荷重の基準値の決定、または地震保険の保険料算定にも用いられている。ゾーン 1 が最も危険度が高い）に位置している。また、トルコの構造物の 23％は 1980 年前、44％は 1981ｰ2000 年、22％は 2001 年以降構築され、ほぼ 7 割が 99 年大地震の前のものである（トルコ統計局 2015 年資料より）。

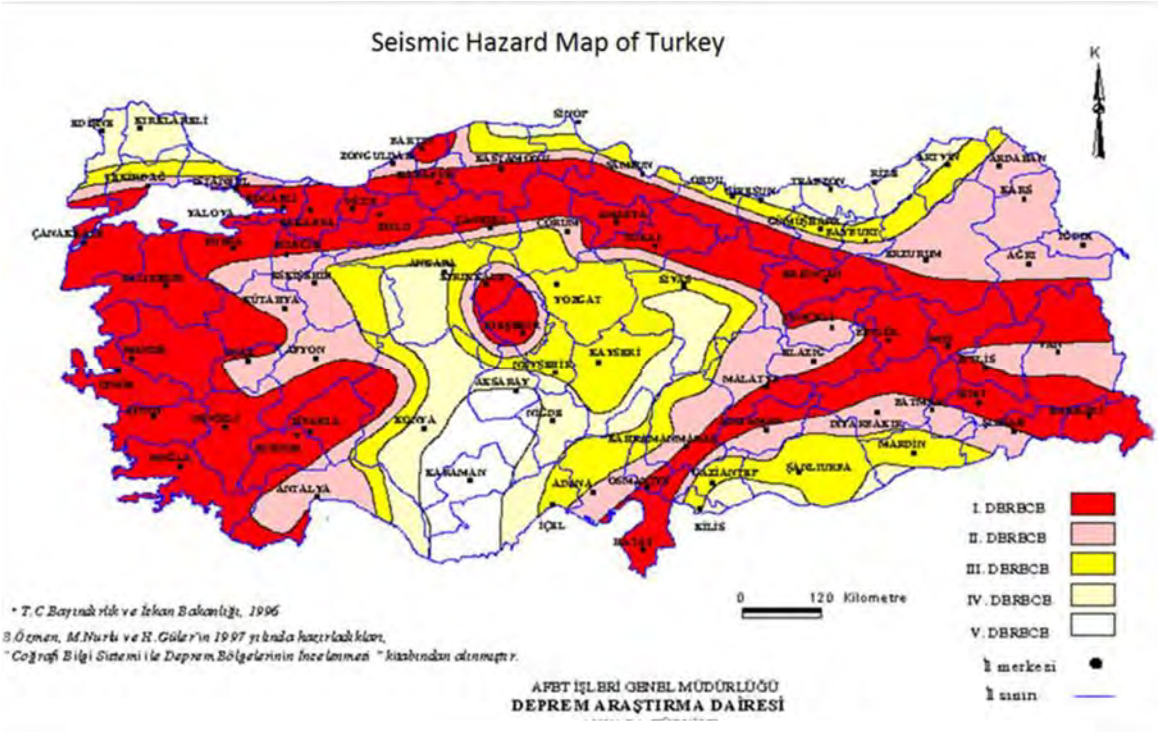


図 2.1-1　ゾーニングされたハザードマップ トルコ統計局 2015 年資料

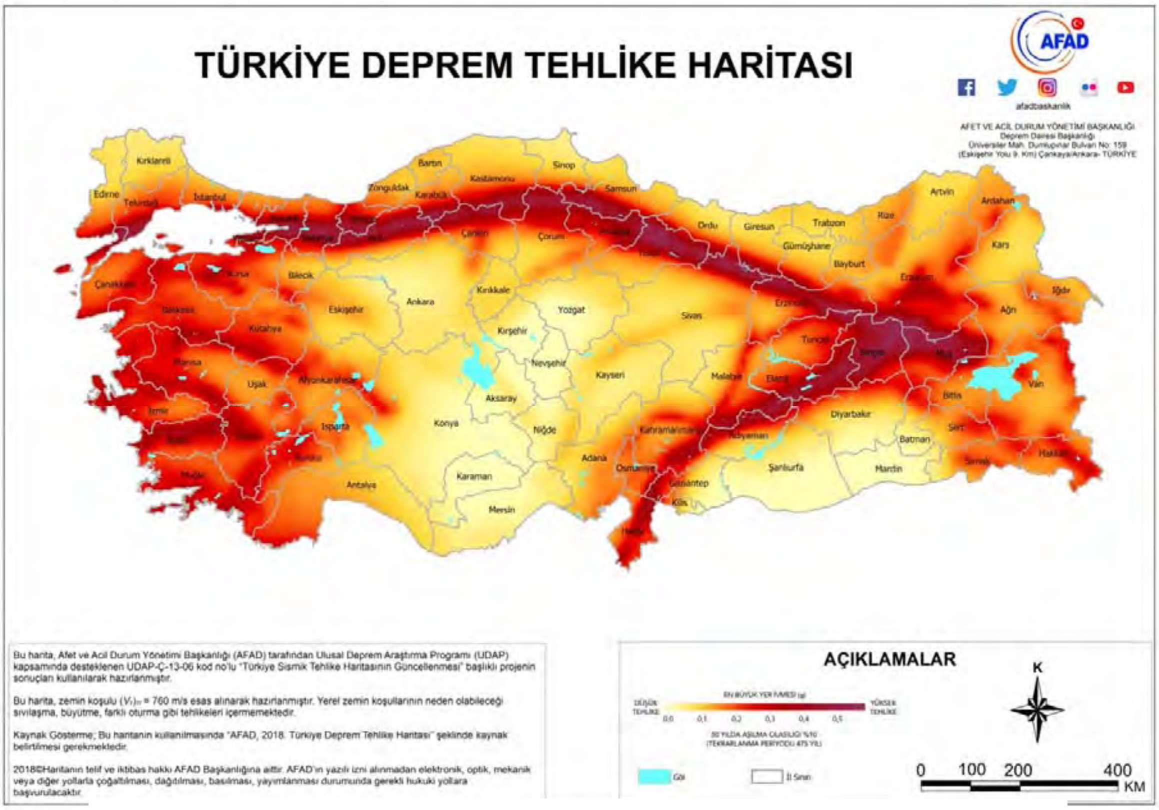


図 2.1-2　トルコの地震ハザードマップ AFAD Web サイトより

2.2. 普及対象とする技術、及び開発課題への貢献可能性

2.2.1. 普及対象とする技術の詳細

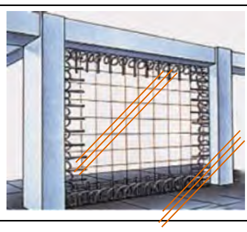
日本で前田建設を含む複数の企業、大学により共同開発された耐震補強技術 MF 構法は、日本国内で学校、庁舎、住宅、事務所ビルなどの耐震補強で実績を重ねている。MF 構法は、新しく開発されたディスクアンカーを用いた外付け鉄筋コンクリートフレームによる補強で建物の耐震化を図る。MF 構法の特徴は、従来の外付けフレームによる耐震補強工法に比べて低騒音、低振動で施工でき、工事のために建物内部に立ち入る必要はないため建物を供用しながら外部にて工事をする「居ながら施工」が可能なことである。また、既存の建物構造を利用し、窓などの開口部を遮らない設計思想であるため、採光や眺望が悪くなることもない。MF 構法を導入することで、耐震補強工事のために建物の利用を制限することが好ましくない公共施設、学校や病院などの耐震化、また民間の工場、事務所棟などの耐震化推進に貢献できると考えている。

MF 構法は、既存建物を対象とした耐震補強技術であり、新築建物を対象としたものではない。新開発したディスクアンカーを用いるのが大きな特徴であり、このディスクアンカーは従来アンカーに比べて高いせん断耐力を発揮するため、従来工法と比較して１／３～１／２にアンカーの使用本数を減らすことができる。

また従来工法では、既存建物のコンクリート表面を斫って目粗しをし、外付けフレームとの付着力をあげることでせん断耐力を補うが、ディスクアンカーは十分なせん断耐力を有するため、これを用いれば斫って目粗する必要がなくなる。その効果として、工事中の騒音、振動、粉塵が著しく低減され、工事中であっても建物の継続使用すなわち「居ながら施工」が可能となる。更に、外付けのフレームによる補強であり、既設構造物に沿って補強する設計思想であるため、開口部（窓）の採光や眺望を悪化させることがない。

MF 構法と日本国で採用されている耐震補強構法との比較を表 2.2.1-1 に示す。

表 2.2.1-1 日本国内における競合技術との比較 （提案法人作成）

	① 提案技術 MaSTER FRAME 構法	② 競合他社技術 鉄筋コンクリート耐震壁補強	③ 競合他社技術 鉄骨ブレース補強
製品・技術画像			
発売開始年	2010 年	1981 年頃	1985 年頃
特徴（強み、弱み）	【強み】 ・補強後も眺望や採光が確保される ・建物を使用しながらの施工が可能 ・補強後も建物の機能が変わらない ・工事中の騒音、振動、粉塵が少ない	【強み】 ・比較的低コストで耐力の向上が見込まれる 【弱み】 ・大きな開口を設けることができない ・設置する場所により、建物の機能が損なわれる	【強み】 ・比較的軽量 ・耐力の向上が見込まれ、ある程度の開口を設けることができる 【弱み】 ・鉄筋コンクリートに比べると高価

	【弱み】 ・敷地に余裕が必要 ・柱が外部に面している必要がある	・施工中に工事個所周辺は使用不可 ・施工中に騒音、振動、粉塵が発生	・設置する場所により、建物の機能が損なわれる ・施工中に工事個所周辺は使用不可 ・施工中に騒音、振動、粉塵が発生
工期	'① と ② は同程度だが ③ は比較的工期は短い		
技術の分類 （大分類） （小分類）	耐震補強 外付鉄筋コンクリートフレーム補強	耐震補強 増設耐震壁補強	耐震補強 鉄骨枠組ブレース補強
機能①	地震に対する耐力の向上	地震に対する耐力の向上	地震に対する耐力の向上
機能②	採光性・眺望性の確保可能	採光性・眺望性が大幅に犠牲になる可能性あり	採光性・眺望性が犠牲になる。
機能③	せん断力に対して独自アンカーが高い効果を発揮。		
価格（単価）	約 200 万円／構面	約 150 面円／構面	約 350 万円／構面
経済性	他の構法との比較で、遜色なし。	低コストが期待可能。	鋼材を利用するため比較的高額
操作性	N/A	N/A	N/A
耐久性（メンテナンス性）	コンクリート製のため耐久性に優れ、メンテナンスが不要	コンクリート製のため耐久性に優れ、メンテナンスが不要	鋼材の錆等の発錆により定期的なメンテナンスの必要あり。
安全性	特別な危険要因はない。	同左	同左
環境への配慮	建物の長寿寿命化、施行中の低騒音、低振動、低粉塵	建物の長寿寿命化	建物の長寿寿命化
日本国内シェア	数%	70-80%程度か	10-20%程度か
海外シェア	なし	70-80%程度か	10-20%程度か
日本国内施工実績（導入例）	32 棟、約 400 構面	一般工法のため多数。	一般工法のため多数。
海外販売実績	なし	海外でも一般的	海外でも一般的
特記事項	日本で「特許権」取得済み	技術的新規性・先進性なし	技術的新規性・先進性なし
競合選定理由	-	従来技術による一般的な補強工法	従来技術による一般的な補強工法

またトルコにおける一般的な耐震補強構法との比較を表 2.2.1-2 に示す。

表 2.2.1-2 トルコにおける一般的な耐震補強構法との比較（提案法人作成）

	提案技術 MaSTER FRAME 構法	競合他社技術 鉄筋コンクリート増設壁補強	競合他社技術 鉄骨ブレース補強
製品・技術画像			
発売開始年	2010 年	1999 年頃	1999 年頃
特徴（強み、弱み）	【強み】 ・補強後も眺望や採光が確保される ・建物を使用しながらの施工が可能 ・補強後も建物の機能が変わらない ・工事中の騒音、振動、粉塵が少ない 【弱み】 ・敷地に余裕が必要	【強み】 ・比較的低コストで耐力の向上が見込まれる 【弱み】 ・大きな開口を設けることができない ・設置する場所により、建物の機能が損なわれる ・施工中に工事個所周辺及び建物は使用不可 ・施工中に騒音、振動、粉塵が発生	【強み】 ・比較的軽量 ・耐力の向上が見込まれ、ある程度の開口を設けることができる 【弱み】 ・鉄筋コンクリートに比べると高価 ・設置する場所により、建物の機能が損なわれる ・施工中に工事個所周辺は使用不可 ・施工中に騒音、振動、粉塵が発生
技術の分類 （大分類） （小分類）	耐震補強 外付鉄筋コンクリートフレーム補強	耐震補強 増設壁補強	耐震補強 鉄骨枠付きブレース補強
機能①	地震に対する耐力の向上	地震に対する耐力の向上	地震に対する耐力の向上
機能②	採光性・眺望性の確保可能	採光性・眺望性が大幅に犠牲になる可能性あり	採光性・眺望性が犠牲になる。
機能③	せん断力が大きい独自アンカーにより本数を約 1/3 に低減できる。		
価格（単価）	応用事例がない為　N/A	約 6.000 円～15.000 円／㎡	約 9.200 円～21.500 円／㎡
経済性	他の構法との比較で、遜色がない見込み	低コストが期待可能。	鋼材を利用するため比較的高額
操作性	N/A	N/A	N/A

耐久性（メンテナンス性）	コンクリート製のため耐久性に優れ、メンテナンスが不要	コンクリート製のため耐久性に優れ、メンテナンスが不要	鋼材の発錆に対して定期的なメンテナンスの必要あり。
安全性	特別な危険要因はない。	同左	同左
環境への配慮	建物の長寿命化、 施行中の低騒音、低振動、低粉塵	建物の長寿寿命化	建物の長寿寿命化
対象国内シェア	なし	80－90%程度	10－20%程度
海外シェア	なし	70－80%か	20－30%か
対象国販売実績（導入例）	なし	一般工法のため多数	一般工法のため多数
海外販売実績（導入例）	なし	海外でも一般的	海外でも一般的
特記事項	・トルコで意匠並びに商標出願済み ・トルコで提案技術に似た補強構法は存在しない	技術的新規性・先進性なし	技術的新規性・先進性なし
競合選定理由	-	従来技術による一般的な補強工法	従来技術による一般的な補強工法
技術の評価	・建築技術性能証明取得済、特許権取得済み。トルコに対する特許権取得出願中、2012 年エンジニアリング協会功労者賞受賞、2015 年前田建設社長表彰奨励賞受賞	在来工法	在来工法

日本国内における前田建設及び共同開発した東洋建設株式会社の施工実績を表 2.2.1-3 に示す。

表 2.2.1-3 MF 構法の施工実績一覧（提案法人作成）

前田建設（関連会社含む）　施工実績						
No.	段階	設計	施工	物件名（工事名称）	施工年度	場所
1	竣工	前田	前田	三田松聖高等学校耐震補強工事	H22 年度	兵庫県三田市
2	竣工	前田	前田	市川市立第八中学校校舎耐震補強工事	H22 年度	千葉県市川市
3	竣工	前田	前田	市川市立大洲中学校校舎耐震補強工事	H22 年度	千葉県市川市
4	竣工	前田	前田	石原産業㈱中央研究所 2 号棟耐震補強工事	H22 年度	滋賀県草津市
5	竣工	日本工房（前田建築事務所）	藤建設（前田）	船泊中学校校舎棟耐震改修	H24 年度	北海道礼文郡
6	竣工	廣陌	砂原組	可部小学校校舎耐震改修(2-2 棟)	H24～25 年度	広島県広島市
7	竣工	廣陌	砂原組	可部小学校校舎耐震改修(1-4 棟)	H24～25 年度	広島県広島市
8	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(本館 A 棟)	H24～25 年度	宮城県仙台市
9	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(本館 B 棟)	H24～25 年度	宮城県仙台市
10	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(寄宿舎棟1)	H24～25 年度	宮城県仙台市
11	竣工	前田	前田	関西ペイント尼崎事業所事務本館耐震工事	H25 年度	兵庫県尼崎市
12	竣工	日本工房（前田建築事務所）	藤建設（前田）	礼文町立香深(カフカ)中学校校舎耐震改修	H25 年度	北海道礼文郡
13	竣工	前田建築事務所	東海興業	姫島青風寮耐震改修	H25 年度	愛知県東海市
14	竣工	味の素ｴﾝｼﾞ（前田）	前田	味の素東海事業所厚生館	H25 年度	三重県四日市市
15	竣工	久米設計（前田建築事務所）	前田	北海道大学総合研究棟(薬学系)	H26 年度	北海道札幌市

16	竣工	味の素ｴﾝｼﾞ（前田）	前田	味の素東海事業所本事務所棟	H26 年度	三重県四日市市
17	竣工	アーバンクリエイト	安藤・ハザマ	東都銀座ビル	H26 年度	東京都中央区
18	竣工	前田	FBS	シャルトル聖パウロ修道女会八代修道院	H27 年度	熊本県八代市
19	竣工	前田	前田	川崎穴水ビル事務所棟	H27 年度	神奈川県川崎市
20	竣工	東洋設計（山田構造デザイン）	FBS	食糧学院第2校舎	H27 年度	東京都世田谷区
21	竣工	東洋設計（山田構造デザイン）	FBS	食糧学院第3校舎	H27 年度	東京都世田谷区
22	竣工	日本工房（前田建築事務所）	若狭組・亀田工業 JV（前田）	上ノ国町役場庁舎	H28 年度	北海道檜山郡
23	竣工	宇田川設計	丸高工業	朝日野方マンション	H28 年度	東京都中野区
24	竣工	日本工房（前田建築事務所）	高木・川瀬経常建設 JV（前田）	木古内町産業会館	H29 年度	北海道上磯郡

東洋建設　施工実績

No.	段階	設計	施工	物件名（工事名称）	施工年度	場所
1	竣工	中神設計	東洋	豊橋技術科学大学　高師住宅1号棟耐震改修工事	H22 年度	愛知県豊橋市
2	竣工	古居構造設計	東洋	旭テック㈱　市田寮耐震補強工事	H23 年度	愛知県豊橋市
3	竣工	中神設計	藤代建設	豊橋技術科学大学　第 2 期 No.1	H23 年度	愛知県豊橋市
4	竣工	中神設計	藤代建設	豊橋技術科学大学　第 2 期 No.2	H23 年度	愛知県豊橋市
5	竣工	中神設計	藤代建設	豊橋技術科学大学　第 2 期 No.3	H23 年度	愛知県豊橋市
6	竣工	中神設計	藤代建設	豊橋技術科学大学　第 2 期 No.4	H23 年度	愛知県豊橋市
7	竣工	古居構造設計	白鳥工務店	春日井市立 柏原中学校耐震補強工事	H24 年度	愛知県春日井市

8	竣工	古居構造設計	近藤組	近藤組本社ビル耐震補強工事	H24 年度	愛知県刈谷市
9	竣工	伊藤構造技術研究所	ファーストカルデア	コンド瀬田耐震補強工事	H26 年度	東京都世田谷区
10	竣工	㈱マルタ設計	東洋建設	林野庁東営1号宿舎耐震補強工事	H29 年度	東京都江東区

2.2.2. 開発課題への貢献可能性

国土交通省土地・建設産業局では、平成１８・２５・２６年度において、日・トルコ建設産業会議を開催し、トルコ共和国の政府・企業との意見交換を通じて、トルコ共和国が我が国に求める建設技術として、耐震技術が最も着目されていることを確認したとしている。同会議は令和元年 11 月にも開催された。そこでは前田建設も参加し、トルコでの耐震補強技術普及促進事業活動等ご紹介させていただいた。

「トルコ共和国は我が国と同様に国内に多くの断層を有する地震国であり、近年では、1999 年のイズミット地震で大規模な被害を受けて以降、地震対策が喫緊の課題となっている。特に、病院や教育に係わる建物については、その社会的意義により耐震化に向けた優先的な対応が見込まれることに加え、既存の建物を継続的に利用しつつも、耐震工事を着実に推進するといった我が国企業の施工能力の高さを生かした事業展開が見込まれる。」（国土交通省土地・建設産業局国際課による「平成 29 年度トルコ共和国における我が国耐震技術の活用促進のための調査検討業務」の企画競争実施の公示文書より。平成 29 年 2 月 24 日付け）

トルコでは官民の管理する建物における耐震化対策は未だ道半ばである。耐震化対策が進まない理由として、取り壊しで新設するには費用が掛かりすぎること、耐震化工事中に建物の使用を制限することが困難であること等が考えられる。このような場合には MF 構法はその問題点を解決し、需要の隙間を満たす適切な工法に成り得る可能性がある。

トルコでは費用面を重要視するため、施工費が最も安価な耐震壁を構築する耐震化構法が良く採用されているのが実情であるが、その場合建物が工事で占有される。外付け工法により耐震化がなされた事例も見受けられるが、窓がつぶされ採光が阻害されたり、部分的に建物を工事で占有されたり、などの不便が発生している。それらの課題を解決した MF 構法のような構法があると認められれば、建物の耐震化の可能性が一段広がり、トルコの建物耐震化にも貢献できると考えている。

MF 構法を採用する需要がある建物がどの程度存在するのかは現時点では判断できないが、前述したように、公立学校においては多数の耐震化が必要であろうと推測される。MF 構法の需要に適合する案件は少なくはないと考えている。

第3章 本事業の概要

3.1. 本事業の目的及び目標

3.1.1. 本事業の目的

本事業の目的は、「居ながら施工」を可能にする MF 工法を用いて、建物の耐震化が必要だが事業の休業や仮建物手配などの理由で耐震補強が進まない建物等に、総合的なコストを削減した耐震化のソリューションを提供することである。

ただし、MF 工法はトルコでは実用化されていない新しい耐震補強技術であり、新技術の採用においては多くの課題がある。特に建築基準や耐震基準への適合性など、採用の大前提となる法規上の課題がある。新技術であることに加え、外国の技術であることで、法的な基準が達成された場合においても、事業主（発注者）からの信頼を得られるかどうかという面も事業を進めるうえで非常に重要である。

上記課題を踏まえ、対象機関である環境都市計画省と共にイスタンブール工科大学の協力を得て MF 構法の技術検証を実施しトルコ国でも実用可能な技術であることを証明する。また耐震設計手法がトルコと日本で異なるため、トルコの耐震基準にのっとった「耐震設計指針」と「施工指針」を作成し、トルコの業者で設計や施工を実施できるようにする。

普及促進を図るには、トルコにて MF 構法による施工実績を積むことが重要になる。対象機関に MF 構法を用いたパイロットプロジェクトを実施してもらうため、案件の選定をしていただき、その建物に対し MF 構法による耐震補強設計を提供する。前田建設および MF 構法への技術的信頼を得ることを目的として、本邦受け入れ活動を実施し、施工実績、デモ施工の視察や前田建設技術研究所の見学を実施して信頼を得る。

3.1.2. 本事業の達成目標（対象国・地域・都市の開発課題への貢献）

１）MF 構法が、トルコ政府機関が重点背策として進める学校・病院などの公共建物耐震化構法の選択肢となり、その特徴（居ながら施工など）が活かされ効率的な耐震化に貢献し、ゆくゆくは民間部門構造物（住宅や工場等）の耐震化にも貢献するため、技術の検証、設計・施工指針やパイロットプロジェクトの設計を問題なく終えて関係者に理解を示してもらっていること。

２）MF 構法の技術提供・移転は、工事により実際に耐震化が進むことへの貢献のみならず、大学レベルの学術研究対象としても意義があるため、イスタンブール工科大学などの有力大学との技術検証を通じて構造設計モデリングや解析を進めることにより、高いレベルの学術研究成果を得ること。その研究成果を大学と協力して学会などで公表し、広く評価を得る礎にする。

3.1.3. 本事業の達成目標（ビジネス面）

トルコの耐震基準に則った設計指針・施工指針が完成していること。トルコの設計事務所とは MF 構法の技術ノウハウライセンス契約という形を通じて、設計・施工指針を共有しその対価を得ることを目指す。

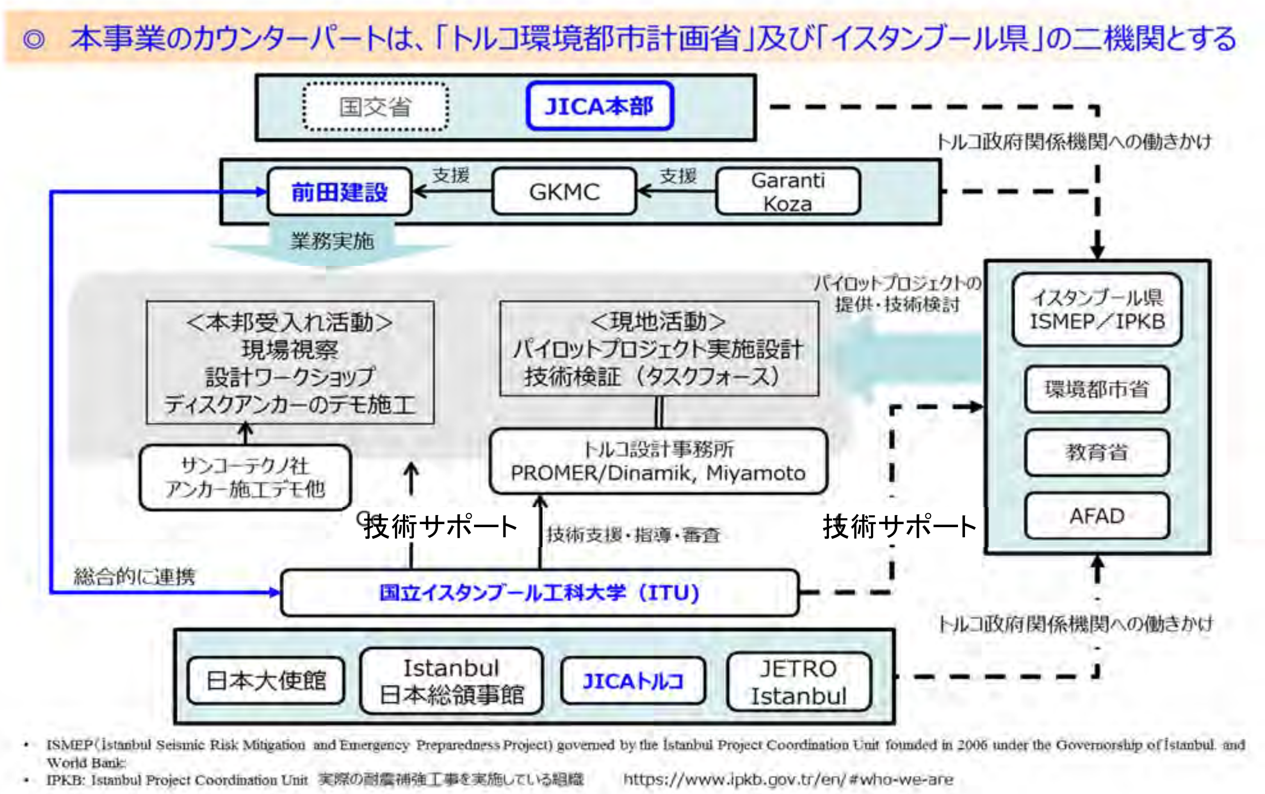
パイロットプロジェクトの耐震補強設計を問題なく完成し、技術的妥当性について承認を得ること。
MF 構法が採用されるか否かはいまだ決定していないが、採用されればディスクアンカーの製造販売というビジネスに直結していく。また実績が作られることで次の案件につながっていくと考えている。

3.2. 本事業の実施内容

3.2.1. 実施スケジュール

本事業契約時点での計画は以下の通り、
技術検証（タスクフォース）および、設計指針策定を 2018 年 12 月までに終えることを目標とする。本邦受入れ活動を 2018 年 9 月頃に実施し、本技術への理解促進を促すものである。
2018 年 10 月頃から、イスタンブール県発注予定のパイロットプロジェクトの選定作業に注力し、その設計業務を同年 12 月までに終える計画とする。但し、パイロットプロジェクトに関してはイスタンブール県の都合で進む要素が多く、計画は都度見直しが必要である。
一連の活動を終えるのを 2018 年 12 月と想定し、トルコで関係者を対象として成果発表を行う。

3.2.2. 実施体制



3.2.3. 実施内容

#	**タスク** **ビジネス展開に向けて事業内に実施すべき項目**	**活動計画** 第1回 '18.08 (現地)	第1回 '18.09 (本邦)	第2回 '18.10 (現地)	第3回 '18.12 (現地)	**実施内容**	**目標（事業終了時の状態）**
1	MF 技術に対する相手国政府機関の理解促進と技術検証の実施					・ITU、環境都市計画省などとタスクフォース（TF）により技術検討、トルコの耐震基準に準拠した設計・施工指針案策定。（18.07 から 4 か月程度、現地）	・政府関係者より、MF 構法はトルコで有効であり、実施可能な技術であるとの認識を得る。

			・日本における実際の施工事例とディスクアンカーのモデル施工を視察、日本の設計技術者とのワークショップ開催（18.09、本邦）	
2	パイロットプロジェクトの設計と大学による技術承認取得		・適切な案件（パイロットプロジェクト）選定と設計事務所の選択と実施設計業務発注（18.10 月頃、現地） ・再委託による設計と ITU による設計内容の審査・納品(18.10-12 月、現地)	・政府関係者より、MF 構法はトルコで有効であり、実施可能な技術であるとの認識を得る。 ・実施設計図書一式を実施機関に納品
3	成果の公開		・セミナー/説明会開催など（18.12 月）	・技術検討成果の公開

第4章 本事業の実施結果

4.1. 技術検証活動（タスクフォース）

MF 構法はトルコでは実用化されていない新しい耐震補強技術である。よっていかに日本国内での実績があっても、トルコ国内でも有効な技術だという事を証明しないことには発注者としても採用するのは難しい。対象機関の環境都市計画省からも大学機関による技術検証がなされることが望ましいという意見があり、2018 年 4 月にタスクフォースを編成し技術検証活動を開始した。トルコでの典型的な学校を想定し、適切な建築物のモデリング、MF 構法で補強する際の構造解析を行いトルコの耐震基準に適合するかどうかを議論するものである。イスタンブール工科大学の准教授に座長を務めていただき、環境都市計画省、設計事務所らや建設会社からの参加者を得て活動をすすめた。主な関係者を表 4.1-1 に示す。

表 4.1-1 タスクフォースの主な活動者（提案法人作成）

所属
ITU, EEDMI, Chairman
ITU, EEDMI
Maeda Corportion, Inventor of MF
Maeda Corporation Representative
Maeda Corporation Civil Eng.
Promer/Dinamik Engineer
ITU MA Student
Garanti Koza, Civil Engineer
GKMC, local coordinator
MoEU, Civil Engineer
MoEU, Civil Engineer
Miyamoto International, Civil Eng.

2018 年 4 月から対象とする建物や条件についての議論を進め、モデリングを終えてからは設計と解析を繰り返した。一連の解析作業を終えて、まとめられた検証結果を 2018 年 9 月 12 日に環境都市計画省にて発表し意見交換を行った。

構造解析モデルは典型的な学校の構造に類似する 4 階建ての耐震壁設置済みの鉄筋コンクリート構造物（図 4.1-1）と、3 階建ての耐震壁の無い鉄筋コンクリート構造物（図 4.1-2）に決定した。

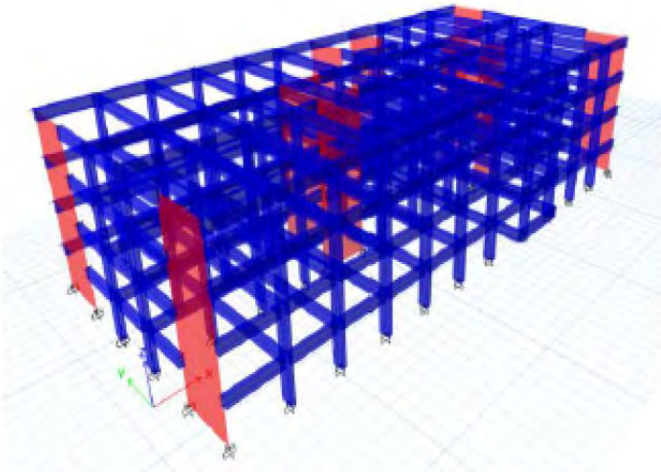


図 4.1-1 解析モデル ４階建て耐震壁（赤色表示）あり、（提案法人作成）

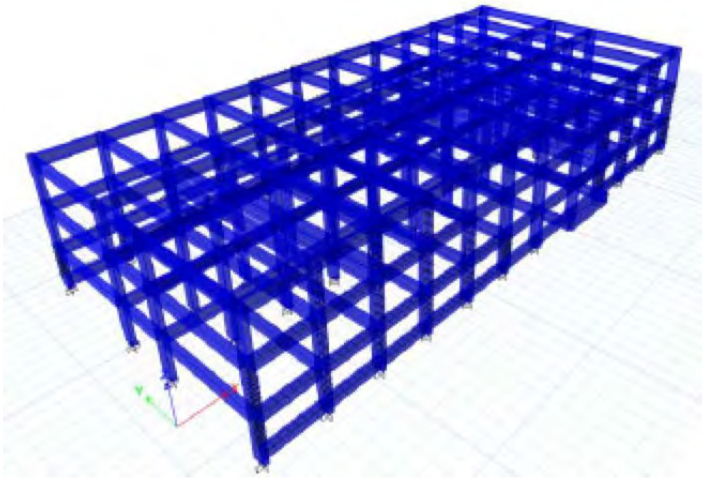


図 4.1-2 解析モデル ３階建て耐震壁なし、（提案法人作成）

主要な解析条件は以下の通りである。

評価する耐震基準	: トルコ国の 2007 年度耐震基準
既設構造物のコンクリート強度	: 15Mpa
解析手法	: プッシュオーバー解析、時刻応答解析
既設構造物の状態	: 500 年周期地震力で深刻な破壊に至る

MF 構法は既設構造物を利用して外付けのフレームで補強する構法のため、既存のコンクリート強度が低すぎると効果がでにくい。実績に基づけば 8Mpa 程度の強度でも補強可能であるが、この度は適切な補強対象を選別する目的もあり上記設定とした。

詳細な解析条件等は添付資料-2 「タスクフォース報告書」を参照のこと。

MF 構法の設計は日本国における設計のノウハウに基づき進め、解析と検討を繰り返して進められた。最終的に設計された MF 構法補強完成外観図を図 4.1-3、4.1-4 に示す。

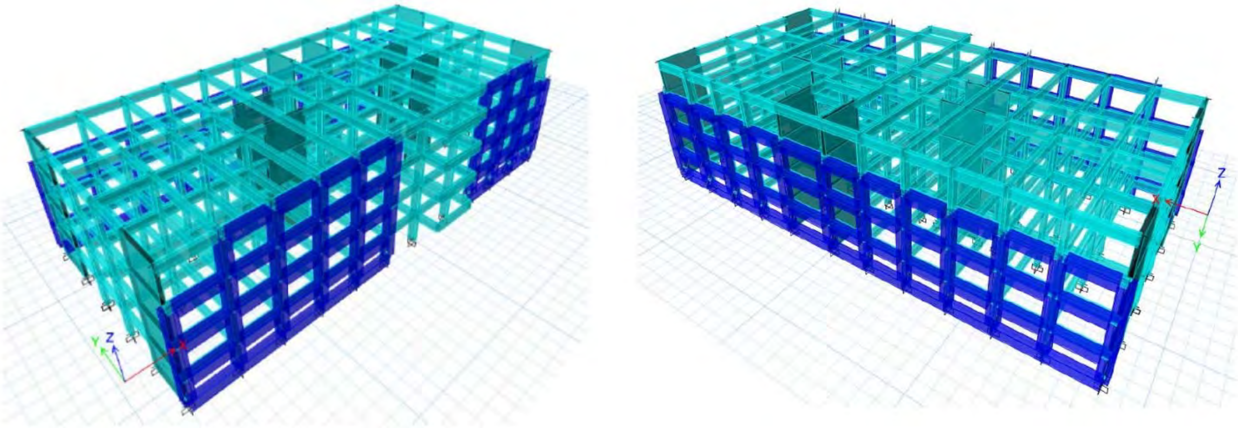


図 4.1-3 MF 構法によって補強された 4 階建て建物（青色部分が補強部分）（提案法人作成）

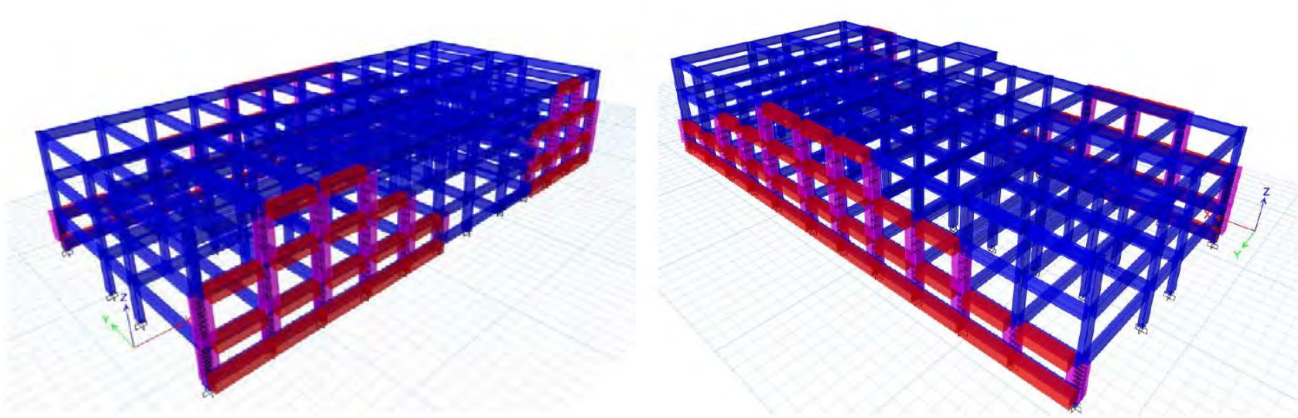


図 4.1-4 MF 構法によって補強された 3 階建て建物（赤色部分が補強部分）（提案法人作成）

解析は、2500 年周期で訪れる大地震規模（Maximum Considered Earthquake：MCE）と 500 年周期で訪れる地震規模（Design Base Earthquake：DBE）に対しての耐性をプッシュオーバー解析で検討した。解析の妥当性を比較するために、参考として、実際の地震波を用いた時刻応答解析を DEB に対して行った。

一連の結果はイスタンブール工科大学の確認を経て報告書にまとめられ、2019 年 4 月に報告書を受領した。

4.2. 設計・施工指針の策定

MF 構法の耐震設計は、既に日本国内での実績があり設計指針も策定されているが、トルコの法規や基準に則った場合、トルコでは用いない構造計算のためのパラメーターがあったり、求められる構造計算が異なったり、そもそものトルコと日本の建物の標準設計が異なったりするなどの違いがある。タスクフォースで得られた技術検証結果を踏まえて、トルコの耐震基準に則って設計指針が策定されることが重要である。

タスクフォースでの技術検証にめどがついた後、2018 年 10 月 20 日にイスタンブール工科大学の構造解析専門の准教授が設計指針の作成に着手した。

2019 年 1 月にトルコで改訂耐震基準が発行された。耐震補強の分野においては大きな改正は無く、地震荷重規定と性能評価について若干の変更があったのみであるが、最新の情報を取り込んで設計指針は策定された。

2019 年 4 月にトルコ語版設計指針が完成し。ついで英語版の簡易版も 4 月中に完成した。

工事については、トルコの建設会社がトルコの設計事務所が完成させた耐震設計図書一式に基づいて工事を実施することになる。ディスクアンカーの施工は品質上重要であるため、施工会社向けの「施工指針」も策定を開始し 2019 年 5 月に完成した。今後は必要に応じて内容改訂を行っていく。

この設計・施工指針は、前田建設の技術ノウハウとして扱い、ライセンス契約先（トルコの業者）に限って提供される。

4.3. 本邦受入れ活動

トルコにおいて新しい技術や製品・サービスが受け入れられるためには、まずは政府機関により採用されることが重要だと考えている。政府期間のパイロットプロジェクトで採用となればその後他の省庁・地方政府にも広がり、さらに民間企業も追従し、技術の採用が拡大する可能性が期待できる。政府関係者からの理解を深めてもらうために本邦受入れ活動を実施し、実際に施工された MF 構法を見学してもらうこと、ディスクアンカーのデモ施工を見学してもらうこと、また前田建設の技術の信頼、理解促進のため技術研究所を視察していただくことを計画し、2018 年 11 月 5 日～8 日に実施した。

主な活動は、以下の通り。

11/5　活動ガイダンスと座学
11/6　仙台市郵政研修センターの MF 構法現場見学
11/7　前田建設新技術研究所の見学
11/8　MF 構法のディスクアンカー設置デモ施工見学

合計 6 名（環境都市計画省 4 名、国民教育省 1 名、イスタンブールプロジェクトコーディネーションユニット（IPKB）1 名）の受入れとなった。他、外部人材や補強人員ら 5 名も活動に参加した。

受入れ参加者（No.１～６）と外部人材、補強人材（No.７～１１）の一覧を表 4.3-1 に示す。

表 4.3-1 本邦受入れ活動参加者一覧 （提案法人作成）

No.		Organization 組織	Title 役職	日本語読み
1	Mr.	Istanbul Project Coordination Unit (IPKB) ｲｽﾀﾝﾌﾞｰﾙﾌﾟﾛｼﾞｪｸﾄｺｰﾃﾞｨﾈｰｼｮﾝﾕﾆｯﾄ	Senior Civil Engineer	シニア土木技術者
2	Mrs.	Ministry of Environment and Urbanisation 環境都市計画省	Asst. General Manager of General Directorate of Construction Work	建設総局副局長
3	Mrs.	Ministry of Environment and Urbanisation 環境都市計画省	Technical Dept. Director of General Directorate of Construction Work	建設総局技術部門長
4	Mr.	Ministry of Environment and Urbanisation 環境都市計画省	Civil Engineer of General Directorate of Construction Work	建設総局土木技術者
5	Mr.	Ministry of Environment and Urbanisation 環境都市計画省	Civil Engineer of General Directorate of Construction Work	建設総局土木技術者

6	Mr.	Ministry of National Education 国民教育省	Genearl Manager of Construction and Real Estate	建設不動産局局長
7	Mr.	Istanbul Technical University ｲｽﾀﾝﾌﾞｰﾙ工科大学	Assistant Professor	准教授
8	Mrs.	Istanbul Technical University ｲｽﾀﾝﾌﾞｰﾙ工科大学	Assistant Professor	准教授
9	Mr.	Promer Engineering and Consultancy ﾌﾟﾛﾒｰﾙ設計事務所	General Manager	役員
10	Mr.	GKMC Construction and Consultancy GKMC 社	Coordinator	ｺｰﾃﾞｨﾈｰﾀｰ
11	Mr.	GK Global BV GK ｸﾞﾛｰﾊﾞﾙ社	Engineer	ｴﾝｼﾞﾆｱ

また、前田建設が新設している先進的な技術研究所の視察を追加した。タスクフォースを通じて設計に関するノウハウについてはトルコの設計事務所や大学と情報を共有しているので、本邦受入れ活動での設計ワークショップは割愛した。

以下に各日程の内容を簡潔に記す。

（初日）
11/5 の午前中には、国交省北村建設流通政策審議官への表敬訪問を行い、政府関係者間での防災協力意識を高めていただいた。午後、前田建設本社に移動し、ガイダンスと座学にて、本活動を行うにあたっての注意点等の説明、前田建設の紹介、改めて MF 構法について紹介、今までの技術検証成果や今後のビジネスモデルについてのプレゼンテーションを行った。

（2 日目）
11/6 の仙台郵政研修センターの MF 構法現場視察では、日帰りでの東京―仙台移動であわただしかったが、現地での見学は予定時間を超えてもまだ視察を続けているなど皆の意識が高待っていることがうかがえた。MF 構法に対する認識を十分もってもらえたと考えている。

（3 日目）
11/7 の前田建設新技術研究所の見学では、特に MF 構法に関する施設の見学ではなかったが、前田建設がもつ先進的な建設技術について、また研究開発に対する姿勢について理解していただけたと考えている。研究所は免震構造になっており、地下の免振構造設備も見学していただいた。やはりトルコ人らは耐震、免震に関わる技術には強い興味があることがうかがえた。

（4 日目）
11/8 の MF 構法のディスクアンカー設置デモ施工見学では、先に簡単なデモのプレゼンを行い、従来工法に比べてどのように騒音や振動のレベルが異なるのかを説明してから、研究棟にて厚さ 50cm ほどの供試体を用いたデモ施工を見学した。デシベル計を用いて騒音を数値化するなど工夫し、確かにディスクアンカーの施工では従来工法に比べて騒音や振動が低減されていることを実感してもらった。

4.4. パイロットプロジェクト設計委託業務

企業機密情報につき非公表

4.5. 成果公表

計画では、タスクフォースでの技術検証結果や、設計指針の概要、パイロットプロジェクト設計の概要などをまとめて実施機関や関連機関を対象にして本事業の成果発表を行うことを計画していた。しかし

ながら、パイロットプロジェクトの設計業務が完了し、設計事務所が概算で求めた総工事費用と全体工期の確認の必要がでてきた。

概算の結果は MF 構法の方が、耐震壁構法よりも安く、かつ早く竣工できるという理想的な結果ではあるものの、日本国内での経験と比較して、工期が短すぎるのではないかという疑問が持ち上がってきた。もしも工期に見誤りがあり、長くなるようであれば、それに起因して工事費も増加する可能性がある。発注者はかねてより費用についてとても敏感で、工事費が大きく異なる、つまり MF 構法の方がより壁構法よりも高いという結論になった場合、パイロットプロジェクトの採用にも影響がでる可能性がある。

そこで、MF 構法はトルコで未実施であることもあり、トルコの建設会社からの情報提供に基づき、前田建設内部においても慎重に検証作業を行う事にした。検証結果が設計事務所の概算と大きく異なる結果となった場合、現地での直接の協議と説明、また大本の発注者となる IPKB にも詳細説明を行う必要があると考えたこと、また、現在までの活動を通じて、MF 構法についての技術的課題をクリアし、関係する政府機関らへの認知度も高まっている中で成果発表の機会を設ける必要が必ずしもないことを勘案し、成果発表のための現地活動は割愛し、必要に応じてパイロットプロジェクトの概算費用、工期の説明のための活動を行うように計画を変更した。

4.6. パイロットプロジェクト設計照査

企業機密情報につき非公表

第5章 本事業の総括（実施結果に対する評価）

5.1. 本事業の成果（対象国・地域・都市への貢献）

MF 構法がトルコで実施可能な技術であるかどうかの検証を行ったタスクフォースの結論は以下の様にまとめられている。

「トルコの耐震基準を満たさないモデル対象において、MF 構法による耐震補強を設計し、解析によりその耐力を検証したところ、損傷の程度は許容内であり工学的に問題がないと判断できる。」

トルコ国内で適用可能な技術であるということがイスタンブール工科大学に認められた。かつ MF 構法を設計するための指針も完成している。MF 構法の特徴である居ながら施工が求められる建物への耐震化を推進する技術的な準備は整ったといえる。

技術への信頼のみならず、企業としての信頼についても本邦受入れ活動を通じて得ることができた。活動に参加していただいた方たちとは、その後も現地合弁会社の GKMC 社を通じて関係を維持できており、MF 構法の可能性にも期待してもらっている。

イスタンブール工科大学と共同での技術検証を進めてきた。これまでの検証結果は大学の研究成果として広く地震学会等の学術機関で研究発表のための材料とすることができる。研究対象としてさらなる改良を加えることも可能であり、今後さらに発展性を広げられる可能性がある。

5.2. 本事業の成果（ビジネス面）、及び残課題とその解決方針

#	タスク ビジネス展開に向けて事業内に実施すべき項目	活動計画と実績 第1回（現地）・第1回（本邦）・第2回（現地）・第3回（現地）	達成状況と評価		残課題と解決方針	解決へのアクションと時期
1	MF 技術に対する相手国政府機関の理解促進と技術検証の実施		完	・タスクフォースを終え MF 構法はトルコでも適用可能な工法であることが ITU から認められた。 ・MF 構法による耐震設計のための指針をトルコ基準に基づき策定した ・本邦受入れ活動を実施し、技術、企業に対する信頼を得た。	・設計指針や施工指針は、今後また耐震基準が変更になるようなことがあれば、必要に応じて改訂していく必要がある。	・随時
2	パイロットプロジェクトの設計と大学による技術承認取得		完	・ISMEP 案件よりパイロットプロジェクトのための案件を選定し設計を現地設計事務所にて行った。設計承認は指定のコンサルタントにより行われ承認された。	・パイロットプロジェクトの工事発注 ・MF 構法の営業。 ・ディスクアンカー生産耐性の確立。	・随時
3	成果の公開→パイロットプロジェクト設計照査		完	・設計に基づき概算された費用と工期について検討し、妥当性について設計事務所へ報告した。	・無し	・

5.2.1. 本事業の成果（ビジネス面）

前述したように、トルコ国内で適用可能な技術であるということがタスクフォースを通じて、イスタンブール工科大学で検証され認められた。図 5.2.1-1 に示すように、MF 構法による耐震補強を施すことで、地震時の建物のせん断耐力が著しく上昇していることがわかる。一連の経過はタスクフォース報告書にまとめられ、今後実施機関への技術説明等に活用することができる。技術検証はもともと環境都市計画省が提案したところに端を発し開始したものである。学校や病院は政府機関が管轄しており、耐震補強工事は政府機関が発注者となることが多い。大学のお墨付きをもらったことで、MF 構法の特徴である居ながら施工要件が需要として認識され、採用される可能性は広がった。

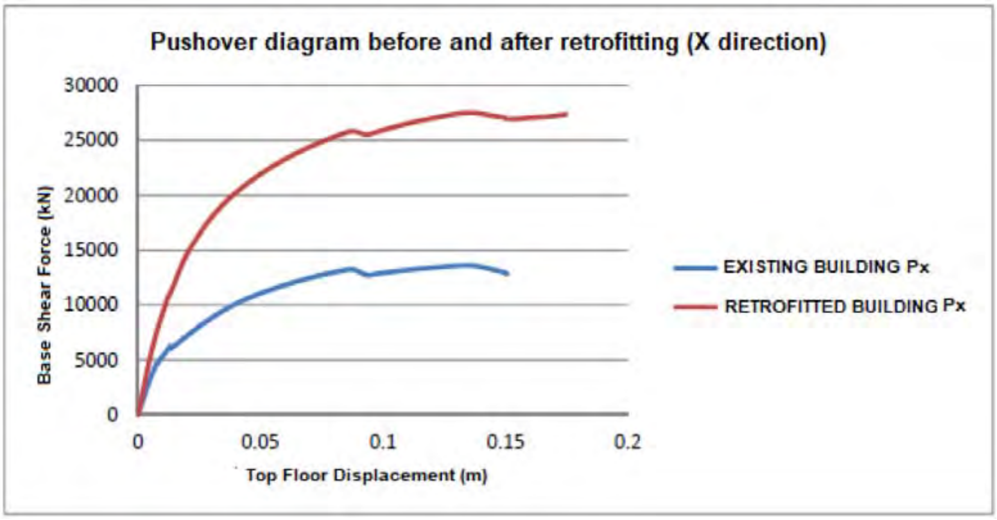


図 5.2.1-1 4 階建て建物モデルのせん断耐力-建物変位相関グラフ（赤線:MF 実施後、青線:既設建物）

（タスクフォース報告書より提案法人作成）

しかし、適用可能な技術だと認められていても、適切な設計が行われなくては意味がないため、日本で確立している設計方法を参考にして、トルコ基準で設計ができるように設計指針を策定した。設計のフローチャートを図 5.2.1-2 に示す。このように、ディスクアンカーの数、設置個所や鉄筋コンクリートフレームの寸法、鉄筋量などを算定し、プッシュオーバー解析と呼ばれる非線形解析を行い建物の耐性を評価していく。このプッシュオーバー解析で破壊性状を判断するのが日本での耐震設計と大きく異なる部分である。本設計指針は今後ビジネス展開していくなかで、設計事務所とのノウハウライセンス契約を結んでいくための材料となる重要な意味を持っている。

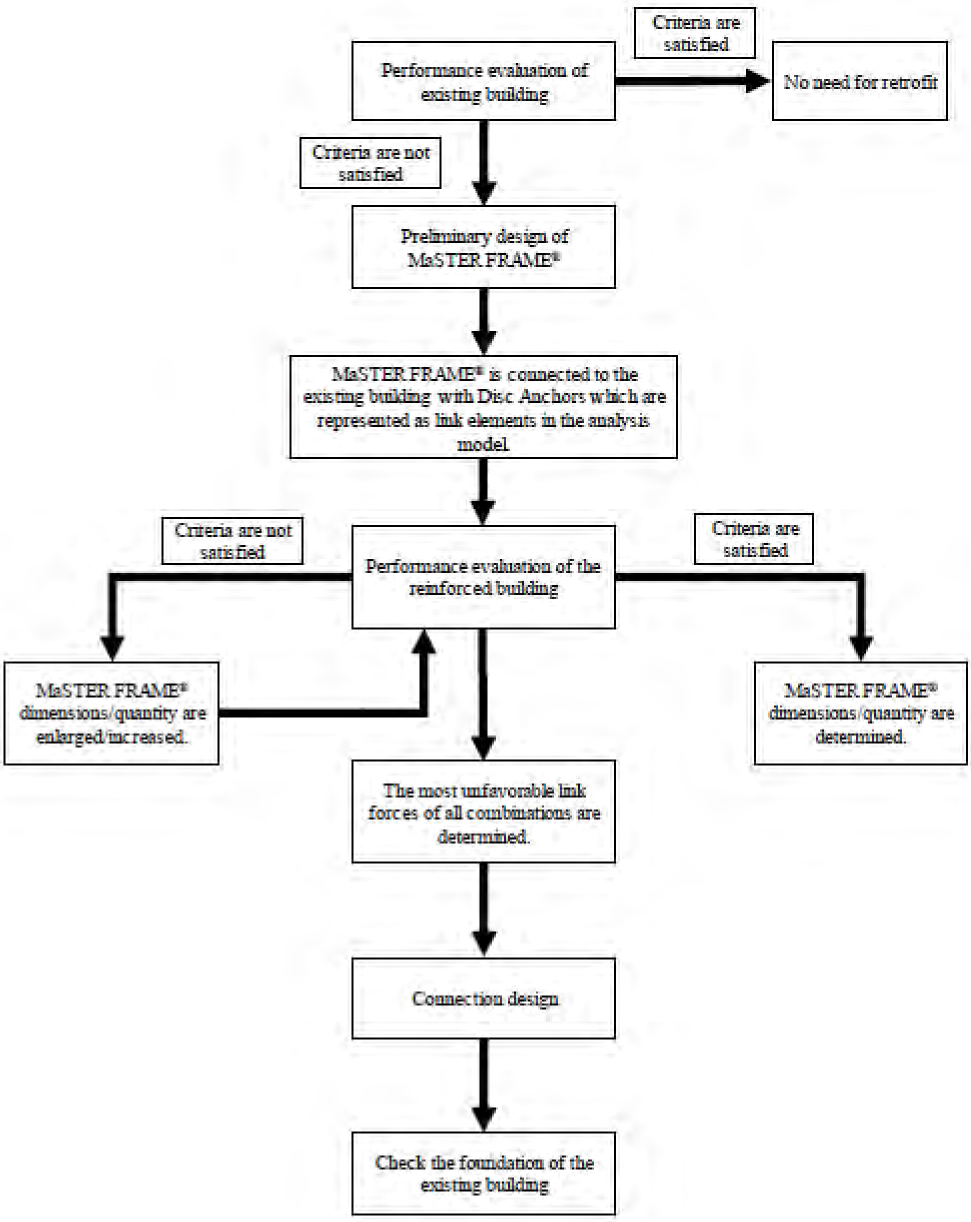


図 5.2.1-2 MF 構法による耐震設計のフローチャート（トルコ基準）（提案法人作成）

パイロットプロジェクトのための実質的な設計を行うことができたことは今後につながる大きな成果である。設計は問題なく終えられ、設計図書一式（設計図面、計算書、仕様書、数量明細表等）が無事完成した。しかしながら、設計事務所の概算費用、工期の見積りの精査の必要があると判断し、これを行った。工期の修正が必要であるものの、費用については大きな変更はないと判断される。現状においても MF 構法が費用、工期の面で従来の耐震壁構法に劣る結果とはなっていない。設計事務所は 2020 年 1 月に、請負ったすべての耐震設計の成果物を MF 構法の設計と合わせて発注元である IPKB に提出する見込みである。

5.2.2. 課題と解決方針

耐震基準は今後も改訂され、条件が変更される可能性がある。設計指針はその都度その影響の程度を判断し、必要に応じて改訂していかなくてはならない。耐震基準は 2019 年に改訂されたばかりであり、今後しばらくは改訂の予定はないとしても、情報収集を怠らず対応していく。

パイロットプロジェクトにて MF 構法が採用されるか否かは、最終的には発注者であるイスタンブール県の裁量による。兼ねてより建物内に耐震壁を構築する従来工法と費用面を比較して検討したいという発言があった。現段階では 100%MF 構法の採用を確約してもらっているというわけではないが、設計に基づく概算金額の比較に基づけば、価格的優位性は認められる。今後はさらなる設計の詳細確認が行われたり、別の懸念自事項が示されたりする可能性は否定できない。直接話を受けたわけではないが、MF 構法は居ながら施工を基本としていることに対して、特に小学校など幼児が建物内にいる場合においては安全面での大きな懸念を抱いているという話もうかがっている。

パイロットプロジェクトが実施されるまでには、今後もいろいろな懸念事項を示される可能性はある。技術面での懸念、日本とトルコでの建物仕様の違いの懸念、費用面での懸念、今までもこれら問題に対応してきた。同じように粛々と、安全面での懸念が示されればその対応や日本での実績、事例を提案し理解を促す努力を継続していく。

本事業活動が終了した後も、このパイロットプロジェクトの意義と今後のトルコ国内での居ながら施工による建物耐震化の可能性を説明して採用のための働きかけを行っていく。

第6章 本事業実施後のビジネス展開の計画

6.1. ビジネスの目的及び目標

6.1.1. ビジネスを通じて期待される成果（対象国・地域・都市の社会・経済開発への貢献）

MF 構法を普及し、ディスクアンカーを製造販売するこのビジネスは、基本的にはトルコ国の社会、業者に利する仕組みになっている。まず MF 構法の特徴（居ながら施工）により建物耐震化の可能性を拡充することができる。今までは、建物内での耐震壁補強が主流であったため、建物を立ち退かなければ施工できないという手間があり、それゆえの耐震化先延ばしが発生している可能性があるが、その問題解決に貢献することができる。そして、耐震壁を構築する従来の耐震補強工法には隠れたコスト、手間と負担が発生している場合がある。建物から退去することを余儀なくされる場合、代替の建物を手配したり、引越ししたりする費用と手間があり、通学する学生が工事中別の学校に通学しなくてはならないなどの負担も予想される。学校などの場合、長期休暇中に施工するなど工夫をして対処している場合もあるようではあるが、MF 構法はこのような問題を解決できる構法である。今後建物の耐震化が大掛かりに進められていく場合、MF 構法が耐震補強構法の一つの選択肢と認識されれば、その社会貢献性は高いと考えている。

6.1.2. ビジネスを通じて期待される成果（ビジネス面）

トルコ国内での建物耐震化が社会的課題にもなっていることは間違いない。しかし、その定量的な需要は正確に把握できないのが現状である。また政府関係者へのヒアリングによれば、耐震化を進めるにあたっての最大の課題は資金調達である。耐震化が必要な公共建物は数万件あると言われているが、耐震診断、設計、建設工事にかかる費用は莫大な金額になる。

耐震化の方法としては、古い建物を解体し新しい健全な建物を建てる方法が費用負担は一番大きい。耐震補強であれば、同じ費用で数件の耐震化を行うことができる。より多くの建物を耐震化していくには、耐震補強が最適であるのは間違いない。よほど老築化した建物を除き、資金面で問題を抱えている現状からも、今後より多くの建物の耐震化を行っていくにあたっては耐震補強が採用されていくだろう。

MF 構法を実施するにあたり、その設計を行うのはトルコの設計事務所であり、施工を行うのもトルコの建設会社である。GKMC 社はトルコの製造業者を通じてディスクアンカーを製造し販売するが、制作するのはトルコのメーカーとなる。設計、施工を通じての利益もトルコ国内の会社に貢献するものである。前田建設は GKMC 社に MF 構法の専属実施権を契約しており、GKMC 社はディスクアンカーを販売する際に技術料を上乗せすることで収益を得るものである。前田建設は将来的にその利益の数%を享受するのみである。この構成は MF 構法が普及した場合に前田建設だけが利益を得るものではなくトルコ国内の社会全体がその利益を得ることができるものである。

6.2. ビジネス展開計画

6.2.1. ビジネスの概要

企業機密情報につき非公表設計事務所

6.2.2. ビジネスのターゲット

企業機密情報につき非公表

6.2.3. ビジネスの実施体制

企業機密情報につき非公表設計事務所

6.2.4. ビジネス展開のスケジュール

企業機密情報につき非公表

6.2.5. 投資計画及び資金計画

企業機密情報につき非公表

6.2.6. 競合の状況

MF 構法は、耐震補強技術としては耐震壁を設置する従来構法と競合する。これは、現状ほとんどの耐震補強工事が従来構法である耐震壁設置構法で行われていることから疑いようがない。但し、MF 構法の特徴である「居ながら施工」の需要はトルコ国内においては限りなく少ない。これは「居ながら施工」の需要がないという事ではなく、既設構造物の機能を阻害せずに居ながら施工を行うことができる構法が存在しなかったからである。つまり居ながら施工による耐震補強工事という括りの中では競合する技術は現段階では存在しない。但しその様な需要は限定的であり、かつ安全面での高い要求が生じることも予想される。

6.2.7. ビジネス展開上の課題と解決方針

企業機密情報につき非公表

6.2.8. ビジネス展開に際し想定されるリスクとその対応策

企業機密情報につき非公表

6.3. ODA 事業との連携可能性

6.3.1. 連携事業の必要性

今まで述べてきたように、建物の耐震化はトルコが早急に解決しなくてはいけない課題として認識されている。MF 構法は建物の耐震化を推進する ODA 事業と連携することができる。MF 構法を採用し、居ながら施工の特徴を生かせば、学校の占有や、休暇中のみの限定された期間内に施工をおこなう必要が無く、うまく計画することで比較的短期間内に多くの建物の耐震化を進めることができる。トルコ共和国の建物耐震化という社会問題解決に ODA 事業として貢献することができるのではないだろうか。日本発祥の技術を用いて耐震化を行うということも ODA 事業として意義があると考えている。

6.3.2. 想定される事業スキーム

トルコ共和国政府の耐震化計画にのっとり、建物の耐震診断や基本設計を進めていく中で、居ながら施工が望ましいと思われる案件を選別し、MF 構法による耐震補強を提案する。

6.3.3. 連携事業の具体的内容

MF 構法は、居ながら施工による耐震補強工事というある特定の需要を満たす構法であるため、すべての建物の耐震化に適切な工法というわけではない。よって連携事業を行うためには建物耐震化の綿密な事前調査が必要である。

学校の耐震化を例にとれば、耐震化が必要な地域を特定して建物の耐震診断を実施する。その結果を、

・取り壊し、建て直しが必要→解体・新築（費用：大、工期：長）

・従来工法（耐震壁、ブレス補強）により耐震化可能→従来工法による補強（費用：小、工期：短）

・建物からの撤去不可、学校休暇中施工困難→MF 構法による補強（費用：小、工期：短～中）

等に分類し、それぞれの分類で最も効果的な耐震工法を選定する。この分類条件を細かくして、条件の中に居ながら施工の必要性を加味することで、MF 構法による耐震化が望ましいといえる案件がある程度明確になってくる。ただしトルコ共和国内では MF 構法を用いた、居ながら施工による耐震補強の実績はいまだない。耐震補強構法の一つの選択肢になるには、今後国内での実績を積む必要がある。

添付資料

- ✧ 添付 1 本邦受入れ活動 研修資料
- ✧ 添付 2 タスクフォース報告書
  イスタンブール工科大学による検証報告””
  設計事務所による解析結果””

参考文献

- ✧ トルコ白地図
  http://www.sekaichizu.jp/atlas/western_asia/country/map_n/n_turkey.html
- ✧ トルコ統計局 2015 年資料
- ✧ ハザードマップ-AFAD ホームページ
  https://www.afad.gov.tr/en/26735/Turkeys-New-Earthquake-Hazard-Map-is-Published
- ✧ 「平成 29 年度トルコ共和国における我が国耐震技術の活用促進のための調査検討業務」
  国土交通省土地・建設産業局国際課

英語要約　SUMMARY

The Republic of Turkey is known as an “earthquake country” with many geologic faults in her territory, and in recent years, large-scale damage occurred caused by the Izmit earthquake in 1999. After that, antiearthquake measures are recognized as a pressing problem. In Istanbul which forms a large metropolitan area, aseismic construction works to schools and hospitals particularly are progressing with the finance by the World Bank and Islamic Development Bank. On the other hand, public facilities including local schools, government office buildings and hospitals are located whole over Turkey, the quick measure implementation is also required to those facilities. Under existing circumstances, it is found that a lot of buildings which need aseismic reinforcement or rebuilding are left without such improvement works. One of the reasons causing the low progress of the aseismic program is considered to as the significant costs of the investigation and the construction, and also temporary relocation and inconvenience due to the restriction of use of existing buildings during the aseismic reinforcing works may be another reason.

A seismic retrofit technology called MaSTER FRAME construction method which is invented by multiple Japanese companies including Maeda Corporation and a university in Japan (hereinafter called MF method) is accumulating a remarkable truck record on seismic retrofitting of schools, government office buildings, housing and office buildings in Japan. MF method promises the seismic retrofitting with the external reinforced concrete frame using the disk anchor which is an exclusively new development. The particular advantage that MF method may promise is that retrofit work is to give rise to lower noise and vibration than those conventional methods using external framing may give rise to and that the building can be used without interruption since no work will be carried out inside the building throughout the construction work. The design concept is to utilize existing structures and not to cover exiting openings by outer framing, thereby keeping lighting and viewing as it is. It is expected that the introducing of MF method will contribute to making aseismic various public facilities, schools and hospitals on which restriction of use is unfavorable or to advancing earthquake-resistance on private buildings and factories as well.

There appears to be compliance issues in terms of the building code and seismic code as a precondition in employing the MF method since MF method is a new technology that has not been practically utilized in

Turkey yet. Given such situations, a Task Force was organized which was dedicated to conduct technical verification jointly with the Ministry of Environment and Urbanization. The assistant professor of Istanbul Technical University was invited to be the chairperson of this Task Force, and in co-operation with some local design offices, the structure modelling and analysis of MF method was conducted to prove the conformability to Turkish buildings and the verification results was reported as a Task Force Report. The Task Force Report can be made best use of as a supporting material to invite relevant authorities to acknowledge that MF method is a very advantageous method for seismic retrofitting.

Knowledge Co-creation Program was conducted to foster a level of reliability of the MF method technology by making available an opportunity of observing actual performance and constructed buildings. Total 6 persons were invited under this Knowledge Co-creation Program (4 persons from Ministry of Environment and Urbanization, 1 person from Ministry of National Education, 1 person from Istanbul Project Coordination Unit (IPKB: an institution implementing ISMEP)). The activities during the invitation were to visit and see the actual construction of MF method done in Sendai City in Japan, visit technical laboratory of Maeda Corporation and the demonstration of installation of disk anchor at the laboratory of Sanko Techno Co., Ltd. which is the supplier of the desk anchor, where they could experience low noise and low vibration.

It was a rushed program, however it is quite certain that the confidence in the technology and company, as they saw and felt actual production, was developed through the program. After the reliability of the MF method was verified through the Knowledge Co-creation Program, the pilot project was due to be carried out by the IPKB or MoEU upon their selecting the building needing aseismic construction work. Thanks to the relevant authorities' great efforts to understand in-depth, the MF method design of the pilot project could be done with the design office which was employed by ISMEP for design works. Upon examination of the contents, a set of design documents was successfully completed. The design office submitted to the implementing authorities these pilot project design documents upon compiling all the design documents which they undertook in accordance with a lumpsum contract they made. We eagerly hope that the employer will conclude financing arrangements, then proceed with tender, commence the work and complete the pilot project of MF method.

In addition to what was stated above, one of main activities was done to write guidelines for design and construction in terms of MF method. The seismic code of Japan and Turkey is different, therefore, the design guideline established in Japan needed to be re-establish in compliance with Turkish seismic code. Turkish seismic code was revised in January 2019 during the project period, so, design guideline was compiled taking due account of compliance with such revision. The design guideline 1st edition was completed with leadership by assistant professor of Istanbul Technical University, a specialist in structural analysis. The construction procedure was established based on the guideline made in Japan since no significant difference was found as regards construction method in both countries.

The business under the project is planned to earn the profit with sales of disk anchor which is the necessary parts of the MF method by GKMC Construction and Consultancy (joint corporation of Maeda Corporation and GK Global BV). To make more price competitiveness and easy procurement, it is planned to produce the anchor in Turkey locally. Negotiation are in progress, with some difficulty though, with multiple manufacturers of disk anchor, however, more time may be needed since there is no assured scheduled rate or quantity of the production and no practical development plan is in sight. It is also required to obtain relevant industrial standards in Turkey. Specifications of MF method has no precedent, it is therefore taking time to conclude process to obtain it. It is scheduled for January 2020 to conclude production system and for March 2020 to obtain the industrial standard.

Among the public buildings needing aseismic construction, the public schools may be given priority in terms of the degree of importance and number. There is no public information in detail available showing the existing conditions whether aseismic construction is necessary or not, but considering the time required for building construction, it is sensible to expect that a lot of public-school buildings may need aseismic construction now. Although the Ministry of National Education is the one holding jurisdiction over public schools, it was once reluctant enough to employ any new technology for aseismic construction, therefore, it was not selected as a direct counterpart for the project. However, the General Manager of Construction and Real Estate of MoNE who joined the Knowledge Co-Creation Program expressed his interest in and understanding of MF method and there seems to be a possibility for the Ministry to adopt MF method in the situation it is necessary and appropriate to utilize MF method.

What relevant authorities, presently carrying out the aseismic program in practice or responsible for implementation of the program, speak out in common is that the program has not advanced because fiscal arrangements have not been secured, thereby causing delay in performing the program. For making buildings aseismic, there would be two ways, one for demolishing existing buildings then rebuilding them, and the other for reinforcing existing buildings. It is common sense that demolishing and rebuilding are costlier, therefore, the application in that way is limited in number. If a large-scale earthquake happens, no one denies any possibility it would cause serious damage in view of current aseismic status. It is important to make aseismic construction on as many buildings as possible, which is one of disaster prevention measures before such disaster occurs. It is expected that if the disaster prevention co-operation progresses between Turkey and Japan, both being prone to earthquake disaster, closely linking with ODA projects, present difficulties found on fiscal funding could be overcome.

添付１　本邦受入れ活動 研修資料

Appendix 1

2018/10/29

The schedule of Knowledge Co-creation Program for Disseminating Japanese Technology for Seismic Retrofitting Engineering Services (MaSTER FRAME(MF) Method) in Turkey

Date		Itinerary	Place	Remarks
4th November (Sun)	AM	02:00 TK52 Departure Ataturk International Airport (IST)		
	PM	19:40 TK52 Arrival Narita International Airport (NRT)		
		20:00~22:00 Transport (NRT-Hotel)	Hotel Metropolitan Edmont Tokyo	Transport by Micro bus
5th November (Mon)	AM	10:30~11:00 Transport (Hotel - Ministry of LIT)		Transport by Micro bus
		11:00~11:30 MoLIIT Kitamura Deputy Director-General	Ministry of LIT	
	PM	11:30~12:00 Transport (MoLIT to Maeda Corporation)		
		12:00~13:00 Lunch	(Restaurant) Luccollina	
		13:00~15:00 Program Guidance	Maeda Corporation, Presentation Room	
		13:00~13:10 Infroduction of Knowledge Co-creation Program		
		13:10~13:30 Greeting from Managing Director Mr.Kibe of Maeda Corporation		
		13:30~14:00 Introduction of Maeda Corporation and MF Method		
		14:00~14:20 Task Force Presentation (Mr.Fatih Sutcu)		
		14:20~14:30 Rest time		
		14:30~14:45 Presentation of Technical Analisys (Mr.Suat Yildirim)		
		14:45~15:00 Explanation of Bussiness Model (Mr.Taner Atici)		
		15:00~15:20 Explanation of program details (Mr.Kobayashi)		
		15:20~15:30 Q&A		
		15:30~15:45 Guide Maeda Corporation Head Office、End		
6th November (Tue)	AM	08:00-08:15 Transport (Hotel to Tokyo Station)		Transport by Taxi
		08:40-10:15 JR Shinkansen Hayabusa7 (Tokyo to Sendai station)		
		10:30-10:50 Transport (Sendai Station to Post Office Training Center)		Transport by Micro bus
		11:00-11:40 Site Visit	Japan Post Holdings Training Centre in Sendai	
	PM	11:50-12:15 Transport (Post Office Training Center to Restaurant)		Transport by Micro bus
		12:15-13:15 Lunch	(Restaurant) Umeno Hana	
		13:15-13:45 Transport (Restaurant to Tohoku Branch Office)		
		14:00-14:45 Q&A and Discussion	Maeda Co. Tohoku Branch Office	
		14:45-15:00 Transport (Tohoku Branch Office to Sendai Station)		Transport by Micro bus
		15:30-17:04 JR Shinkansen Hayabusa24 (Sendai to Tokyo Station)		
		17:30-18:00 Transport (Tokyo Station to Hotel)、End		Transport by Taxi
7th November (Wed)	AM			
		10:30-12:00 Transport (Hotel to Toride)		Transport by Micro bus
	PM	12:00-13:00 Lunch		
		13:00-15:00 Visit Technical Research Center of Maeda Corporation	Maeda Co. Reserch Center	
		15:15-16:45 Transport (Toride to Hotel)、End		Transport by Micro bus
8th November (Thu)	AM			
		11:00-12:00 Transport (Hotel to Nagareyama)		Transport by Micro bus
	PM	12:00-13:00 Lunch		
		13:00-15:00 MF Mehod Disk Anchor instration demonstration	Sanko Techno Co., Ltd.	
		13:00~13:30 Greeting and Explanation of Demonstration		
		13:30~15:00 Demo (Drilling, Chipping, decibel check etc.)		
		15:15-16:45 Transport (Nagareyama to NRT)		Transport by Micro bus
		17:00- Check-in etc TK53 21:25 Departure NRT		
9th November (Fri)	AM	4:10 TK53 Arrival IST		
	PM			

トルコへの
耐震補強技術の提供について
（マスターフレーム構法）

2018年11月05日
北村建設流通政策審議官　説明資料
前田建設工業　国際支店

MaSTER　FRAME構法
外付け鉄筋コンクリートフレーム耐震補強構法

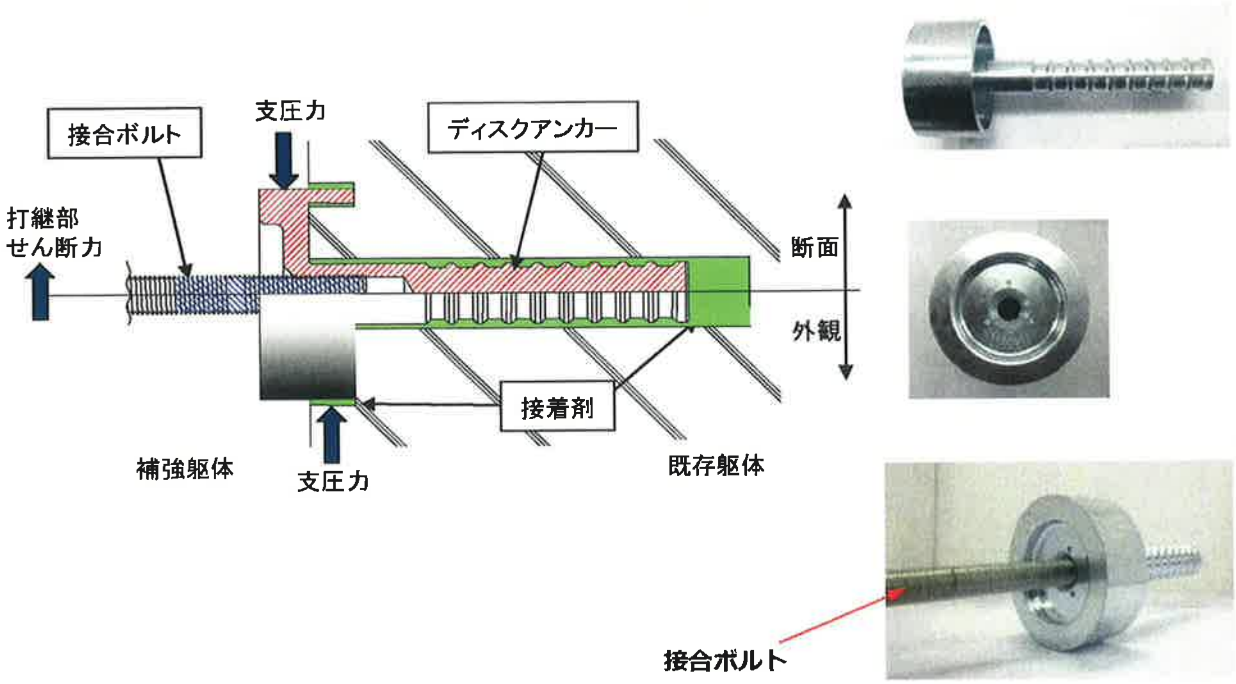
特徴

- 外部からの補強のため、**建物内部には立ち入りません。**
- 専用のあと施工アンカー「**ディスクアンカー**」**を使用し、**騒音・振動・粉塵を低減し、**使用しながらの工事を実現します。**
- 耐震壁による耐震補強構法と比較すると**工期の短縮が可能**です。補強部材をプレキャスト化し、工期を更に短縮できる可能性があります。
- ブレース材（斜材）を取り付けないため、**採光・眺望に影響を及ぼしません。**

2010年3月（一財）日本建築総合試験所より建築技術性能証明を取得
2012年7月（一財）日本エンジニアリング協会「エンジニアリング功労者賞」受賞

MaSTER FRAME構法の特徴

ディスクアンカー（トルコでも特許、意匠、商標出願済）

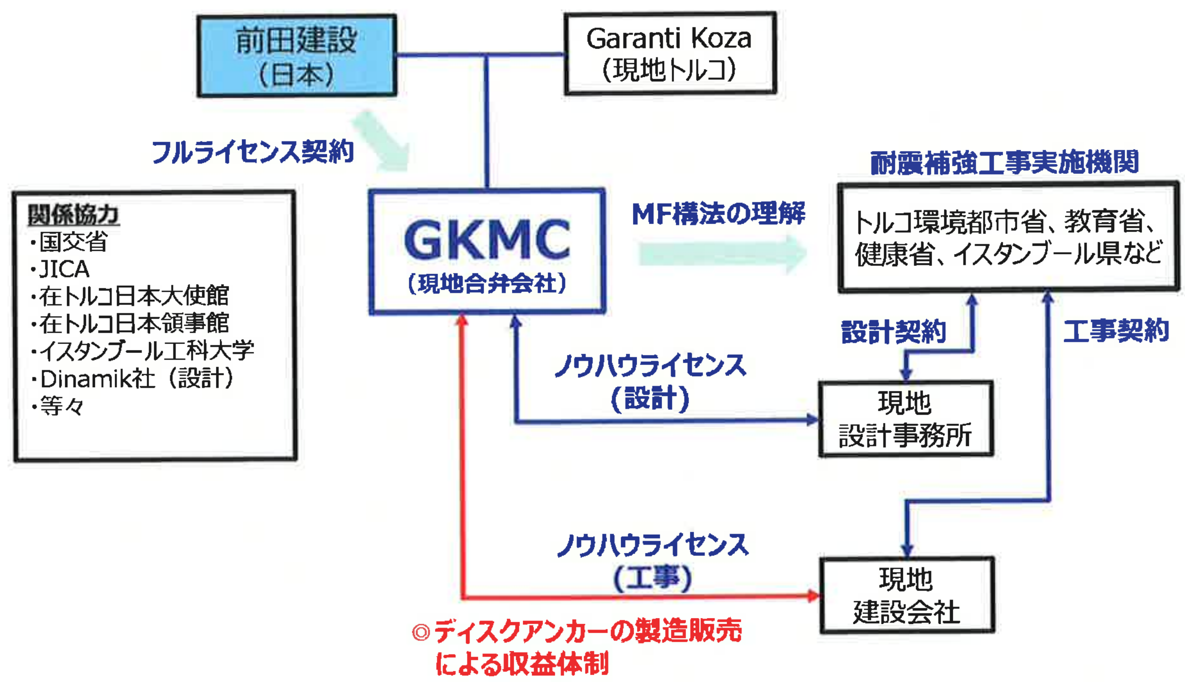


技術移転スキーム案

◎前田の役割は「技術・ノウハウの提供」、**実務はトルコの設計事務所・トルコの建設会社**

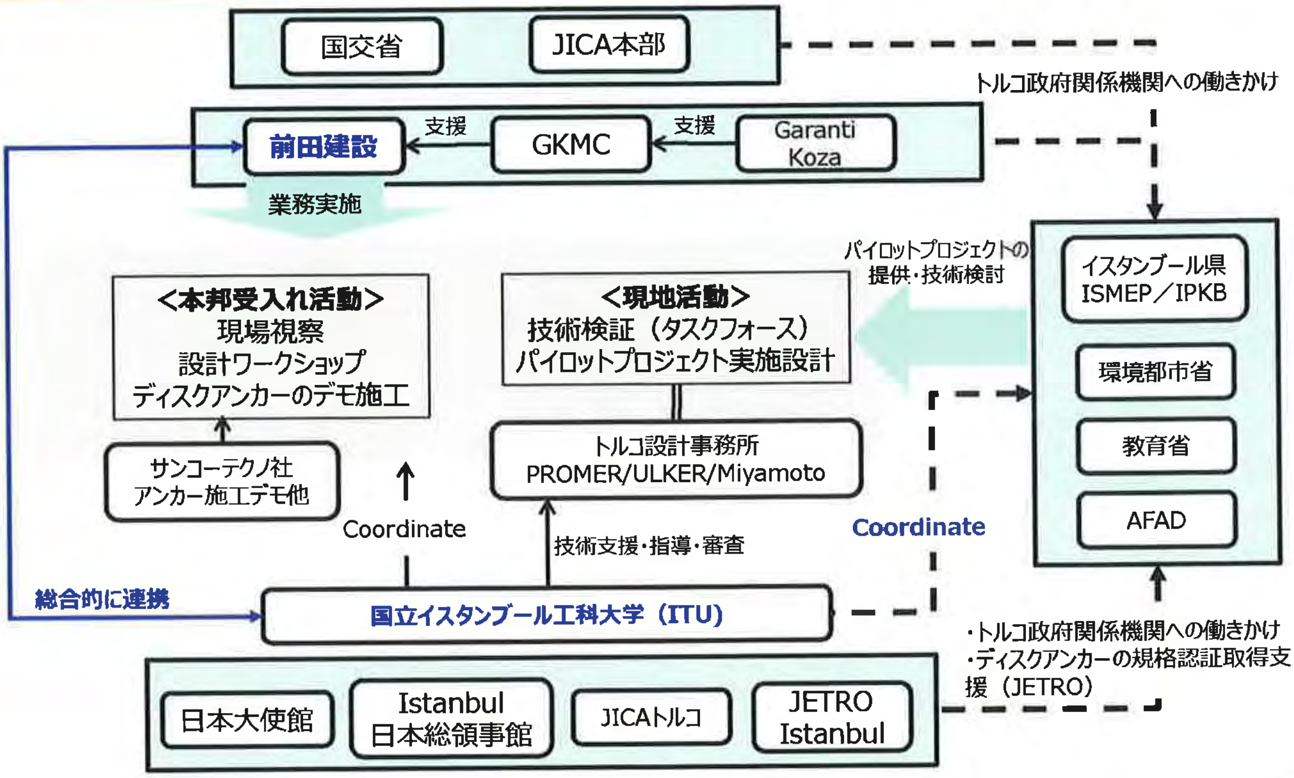
◎**トルコ企業にとって事業性があることが重要⇒主体的な継続性につながる**

◎ライセンスによる体制構築（知財権の出願）



JICA 民間技術普及促進事業 実施体制図

◎ JICA事業のカウンターパートは、「トルコ環境都市省」及び「イスタンブール県」の二政府機関



- ISMEP (İstanbul Seismic Risk Mitigation and Emergency Preparedness Project) governed by the İstanbul Project Coordination Unit founded in 2006 under the Governorship of İstanbul and World Bank:
- IPKB: Istanbul Project Coordination Unit 実際の耐震補強工事を実施している組織　　https://www.ipkb.gov.tr/en/#who-we-are

スケジュール

- ITUにてディスクアンカーのせん断耐力試験実施中、11～12月に完了見込み。
- 7月20日　JICAとの業務委託契約締結　（2018年7月～2019年6月頃まで）
  - ➢ タスクフォース（TF)会議等技術検証業務　7月～11月頃
  - ➢ 9月：トルコでの現地活動：JICA事業開始に伴う事業説明、TF活動報告会を実施。
  - ➢ 10月：MF構法設計ガイドラインの作成開始
  - ➢ 11月：本邦受け入れ活動
    （国交省　表敬訪問、施工事例視察、デモ施工体験など）
  - ➢ 12月：パイロットプロジェクト案件の選定、タスクフォース成果報告書完成

  2019年
  - ➢ 2月：MF構法設計ガイドラインの完成
  - ➢ 3月：パイロットプロジェクト設計業務完了
  - ➢ 4月：現地活動（セミナー開催、IstanbulとAnkara）
- 以降、JICA事業外にてパイロットプロジェクトの工事施工、竣工となるが、実施機関の裁量による。

MaSTER FRAME構法の実績

国内施工実績

◆ 施工棟数

３０棟
北海道～九州

◆ 補強構面数

約４００構面

Before

◆ 建物用途
:私立高等学校
◆ 規 模
:RC造4階
◆ 補強タイプ
:直付工法
◆ 施工
:柱PCa
梁・基礎梁現場打ち
◆ 補強柱
:せい700, 厚さ650

After

MaSTER FRAME構法の施工実績

Before

◆ 建物用途
：公立中学校
◆ 規 模
：RC造４階
◆ 補強タイプ
：直付工法
◆ 施工
：柱・梁PCa
２階梁以下現場打ち
◆ 補強柱
：せい750，厚さ450

After

After

◆ 建物用途
：研究所
◆ 規 模
：RC造３階
◆ 補強タイプ
：直付工法
◆ 施工
：現場打ち
◆ 補強柱
：せい800，厚さ470

MaSTER FRAME構法の施工実績

Before

- 建物用途
  ：研修所・宿泊施設
- 規 模
  ：RC造４階
- 補強タイプ
  ：直付工法、間柱追加
- 施工
  ：現場打ち
- 補強柱
  ：せい750，厚さ500

After

After

- 建物用途
  ：事務所
- 規 模
  ：RC造４階
- 補強タイプ
  ：直付工法
- 施工
  ：現場打ち
- 補強柱
  ：せい600，厚さ500

MaSTER FRAME構法の施工実績

Before

- 建物用途
  ：公立中学校
- 規 模
  ：RC造２階
- 補強タイプ
  ：直付工法
- 施工
  ：現場打ち
- 補強柱
  ：せい600，厚さ500

After

After

- 建物用途
  ：住宅
- 規 模
  ：RC造４階
- 補強タイプ
  ：増設工法
- 施工
  ：現場打ち
- 補強柱
  ：せい850，厚さ700

MaSTER FRAME構法の施工実績

北海道大学

※意匠的にも高い評価

2017 年 10 月 5 日

MF 構法に関する FQA

(For information and discussion purpose)

＜概要＞

1. Q:MaSTER FRAME 構法（MF）とは何ですか？

   A:MF は日本で開発された耐震補強技術（既存の建物を補強するための技術）のひとつです。

   DISK-Ankraj という独自に開発した「あと施工アンカー」を使用し、鉄筋コンクリートのフレームを建物の外側に直接構築するものです。

2. Q:MF 技術の特徴は何ですか？

   A:建物の外側で補強工事を実施するため、工事期間中も建物を継続して使用できることが最大の特徴です。また開口部に設置される鉄骨ブレースなどによる補強では、採光が減り、眺望も悪くなりますが、MF の場合はそうした問題は生じません。

3. Q:実績はありますか。

   A:トルコでの実績はまだありませんが、日本では 30 件程度の実績があります。主に学校、住宅・宿舎、庁舎、研究所などの耐震補強で採用されています。

4. Q:MF で耐震補強された建物は、日本で発生した大きな地震で被害がありましたか？

   A: 仙台市にある郵政省の宿舎を MF で補強したが、2011 年に発生した東日本大震災（マグニチュード 9.0）においてほとんど損傷は見られませんでした。

   A:また、MF で補強した熊本市内にある修道院の宿舎は、2016 年に発生した熊本地震（マグニチュード 7.3）でほとんど損傷は見られませんでした。

5. Q:MF 技術は誰がトルコに提供して、誰が使えるのですか？

   A:GKMC İnşaat ve Danışmanlık A.Ş（本社イスタンブール、日本の大手エンジアリングコントラクターの前田建設工業株式会社と、Garanti Koza 社との合弁会社）が、前田建設からこの技術のトルコでの独占的なライセンスを取得します。この技術を採用した実際の耐震補強設計業務については、トルコのエンジニアリング会社にサブライセンスをして主体的に活用して欲しいと考えています。

6. Q:特許権などはどのようになっていますか。

   A:DISK－Ankraj や工法については前田建設が、トルコ特許庁に特許権、工業意匠権、商標権などを出願済みです。

7. Q:DISK-Ankraj はどのように供給されるのですか。

   A:ディスクアンカーは GKMC が提供します。現在、トルコ国内で製造するための準備中です。初期段階は日本からの輸入になる可能性はあります。

8. Q:MF の技術的な検証はどうなっていますか。

   A:日本では、公的な第三者機関（日本建築総合試験所、GBRC）により日本の基準を用いて技術・性能が審査され 2012 年に「建築技術性能証明書」（GBRC 性能証明　第 09-35 号改）を取得しています。トルコの建築基準や地震コードに適合する構造計算については、今後イスタンブール工科大学と共同で技術的なスタディを進めています。

<技術の詳細について>

9. Q: MF は何階建ての建物に適用可能ですか？

   A: MF による外付けのフレームは 6 層程度が限界だと考えています。既存建物の階数としては 14 階建て程度までの中低層建物に対して効果的です。

10. Q:MF を使えば建物内部に入らず完全に外からの工事のみで済むのですか？

    A:完全に外からの補強が可能な場合もあるし、既存建物の状況にっては内部の補強が必要な場合もあります。MF は、ジャケッティング、壁増設などの他の補強工法と併用可能です。

11. Q:MF を採用した場合、既存構造物との基礎レベルでの繋がりはどのようになりますか？または新たに杭が必要ですか？

    A:基本は、既存建物の基礎梁と MaSTER FRAME の基礎梁とを結合します。必要に応じて、杭が必要になるときもありますし、基礎の補強が必要な場合もあり得ると考えています。

12. Q:MF は、対称的でないまたは複雑なレイアウト（例えば L 型レイアウトの学校）への適用可能性はありますか？

    A:フレームが構築できる形状であれば、MF の適用は可能です。

13. Q:MF のフレームは、表裏両側とも補強が必要でしょうか？また X,Y の二方向補強も可能でしょうか？

    A:一般的には表裏補強が必要になります。表面は MF フレーム補強、裏面は従来のブレース補強あるいは別の補強方法にしても OK です。また XY 両方向を MF のフレームによる補強も可能ですし、X 方向は増設壁にしても OK です。

14. Q:一面のみにフレームが構築される場合、建物の torsion（ねじれ）をどうやって防ぐのですか？

    A:ねじれが生じないようにフレームをバランスよく配置するように設計します。トルコの CODE に応じて耐震壁の増設との併用もあり得ます。

15. Q:耐震性能の考え方として immediate Occupancy(I.O.)と Life Saving(L.S.) レベルがあるが、MF ではどのようにその基準を満たすのですか。

    A:IO や LS レベルというトルコの基準が求める耐震性能を満たす設計が可能です。

16. Q:トルコの特にパブリック教育施設の場合コンクリート強度が低いことが多いが、MF が適用可能な最低コンクリート強度はどの程度ですか？

    A: 8 MPa 以上の強度があれば MF が適用可能だと考えています。

17. Q:DISK-Ankraj は一般的なあと施工アンカーと何が違うのか。

    A:DISK-Ankraj はデイスクが直接せん断力を負担するためアンカーの埋め込みの深さが一般的なアンカーより短くなります。つまりアンカー埋め込み作業において既存の柱や梁内部の鉄筋が支障となる場合が大幅に減る。

    A:DISK－Ankraj はせん断強度が一般的なアンカーと比較して高いので、アンカーの本数自体を大幅に減少（1／2 から 1／3 に減る）でき、既存躯体コンクリートの目粗しが不要となり、騒音、粉じん、振動が従来工法と比べて著しく低減できます。

    A:DISK－Ankraj の設置は、専用のビットを付けたコアドリルで削孔し接着剤を注入して定着します。

18. Q:既存建物のスラブ厚が 10cm 程度のものがトルコでは多いが、外側補強で効果が得られるのか？。

    A:10cm 程度であれば、マスターフレーム構法の適用可能です。

19. Q:トルコはコンクリートのかぶり厚が少ないが、アンカーの施工上問題ないのか？

    A:ディスクアンカーの溝を掘るため 20 ㎜のかぶり厚が必要です。

20. Q:コストについての情報はありますか？
A:現在資料を作成中です。外側に構築するフレームは一般的な RC であり、特殊なものはアンカーしかありません。アンカーの本数は大幅に減少しますし、建物内部に入る作業がなくなれば、業務（学校の場合授業）を一定期間中止することや移転のための経費などが不要になります。また内部での耐震補強工事をしないということは内装工事をする必要もなくなります。こうしたことから従来工法と比較しても十分コスト競争力が期待できると考えています。コストのみならず、建物が継続使用できることの意義は十分大きいと考えています。
21. Q:本構法の設計上の理解も重要だが、精度よく正しく施工できるかどうかという課題も重要ではないか？
A:施工会社に対して、施工指導をする仕組みをつくることを考えています。
22. Q:外断熱材 thermal sheathing (insulation)がついている場合は問題はないか？
A:外壁に外断熱材がある場合は、フレームを設置する箇所は断熱材を除去し、その後断熱材を復旧する作業が必要です。
23. Q:構造計算プログラムは特殊なものが必要ですか？
A:マスターフレーム構法のための特別な計算プログラムは必要ありません。

前田建設工業株式会社／GKMC İnşaat ve Danışmanlık A.Ş

5 Ekim 2017

MaSTER FRAME™ SİSTEMİ İLE İLGİLİ SIKÇA SORULAN SORULAR

(Sadece Bilgilendirme ve Tartışma Amaçlıdır)

1. Soru : MaSTER FRAME™ (MF) tekniği nedir?

Cevap : MaSTER FRAME™ Japonya'da geliştirilmiş olan yapısal güçlendirme tekniklerinden biridir (Mevcut yapıları depreme karşı güçlendirmek için geliştirilmiş bir tekniktir.) MaSTER Disk-Ankraj™ olarak adlandırdığımız ve özel olarak geliştirmiş olduğumuz ankrajları (kimyasal dübel) kullanarak betonarme çerçevelerin mevcut binaya dışarıdan uygulanması esasına dayanır.

2. Soru : MaSTER FRAME™ (MF) tekniğinin özelliği nedir?

Cevap : Güçlendirme uygulamasının mevcut yapının dışında yapılması ve inşaat süresince yapının kullanıma devam ediyor olması en büyük özelliğidir. Ayrıca yapı açıklıklarına yerleştirilen çelik çaprazlar ile yapılan güçlendirmelerde yapıya giren güneş ışığı azalmakta ve yapının görüntüsü bozulmakta olup, MaSTER FRAME tekniği ile yapılan güçlendirmede bu sorunlar ortadan kalkmaktadır.

3. Soru : Uygulanmış örnekler mevcut mudur?

Cevap : Türkiye'de henüz uygulanmış bir örnek olmamakla birlikte Japonya'da 30 üzerinde yapıda uygulanmış örnek mevcuttur. Özellikle okul, konut, yurt, kamu binaları, araştırma merkezleri ve benzeri yapılara bu teknik başarı ile uygulanmıştır.

4. Soru : Japonya'da meydana gelmiş depremler esnasında MF ile güçlendirilmiş yapılarda herhangi bir hasar/zarar oluşmuş mudur?

Cevap : Sendai şehrinde Posta ve Telekomünikasyon Bakanlığı'na ait bir konut MF ile güçlendirilmiş olup, 2011 yılında meydana gelmiş olan Büyük Doğu Japonya Depremi'nde (9.0 büyüklüğünde) yapıda hemen hiç zarar oluşmamıştır.

Aynı şekilde, Kumamoto şehrinde MaSTER FRAME™ ile güçlendirmiş olduğumuz bir tapınağa ait yurt, 2016 yılında meydana gelmiş olan Kumamoto Depremi'nde (7.3 büyüklüğünde) hemen hiç zarar görmemiştir.

5. Soru : MaSTER FRAME Teknolojisini kim Türkiye'ye getirecek ve kimler yararlanacaktır?

Cevap : GKMC İnşaat ve Danışmanlık A.Ş (Merkez ofis İstanbul'da olup, Japonya'nın büyük mühendislik ve genel müteahhitlik firmalarında Maeda Corporation ile Garanti Koza İnşaat ve San. Tic. A.Ş tarafından eşit ortaklıkla kurulmuş şirket) Maeda Corporation firmasından bu teknolojinin inhisari lisans haklarına sahip olacaktır. Bu güçlendirme tekniğinin Türkiye'deki tasarım ve mühendislik işleri ile ilgili olarak GKMC Türk mühendislik firmalarına alt lisans vermeyi düşünmekte, MF teknolojisinin Türkiye piyasasına girişinde Türk firmalarının ana unsur olarak yer almalarını istemektedir.

6. Soru : Patent gibi fikri ve sınai haklar ile ilgili bilgi verir misiniz?

Cevap : MaSTER Disk-Ankraj^{TM} ve teknik ile ilgili olarak Maeda Corporation, Türk Patent Ofisi'ne patent, endüstriyel tasarım ve marka tescil başvurularını tamamlamış bulunmaktadır.

7. Soru : MaSTER Disk-Ankraj^{TM} nasıl tedarik edilecektir?

Cevap : Disk-Ankrajları GKMC tedarik edecektir. Bu ankrajların Türkiye'de üretimi ile ilgili çalışmalarımız devam etmektedir. İlk aşamada Japonya'dan ithal etme olasılığı da mevcuttur.

8. Soru : MF ile ilgili teknik tasdik ve onay çalışmaları hakkında bilgi verir misiniz?

Cevap : Japonya'da resmi ve bağımsız bir kurum (General Building Research Corporation of Japan、GBRC) tarafından Japonya'da kanun ve yönetmeliklere uygun olarak MaSTER FRAME teknik ve performans açısından değerlendirilmiş ve 2012 yılında "Yapı Teknolojileri Performans Sertifikası" nı (GBRC Sertifikası - No:09-35) elde etmiştir.

Türkiye'deki ilgili mevcut deprem yönetmeliğine uygun hesap yonteminin geliştirilmesi ile ilgili olarak İstanbul Teknik Üniversitesi ile ortak olarak yürüttüğümüz teknik çalışmalarımız devam etmektedir.

TEKNİK ÖZELLİKLER ile İLGİLİ SORULAR

9. Soru : MF'in kaç kata kadar uygulanması mümkündür?

Cevap : MF çerçeveleri en fazla 6 kat yüksekliğinde uygulanmaktadır. MF çerçeveleri 14 kata kadar (orta yükseklikteki) olan mevcut yapıların güçlendirilmesinde etkili bir sistemdir.

10. Soru : MF sistemi uygulandığında yapının içine girmeden, tamamen dışarıdan yapılacak uygulama (inşaat) yeterli midir?

Cevap : Tamamen haricen uygulamanın yeterli olacağı uygulamalar olduğu gibi mevcut yapının durumuna göre yapının içinde de güçlendirme yapılmasının gerektiği durumlar olabilir. MaSTER FRAME^{TM}, mantolama, perde-duvar eklenmesi gibi yöntemlerle birlikte uygulanması mümkün olan bir yöntemdir.

11. Soru : MF çerçevesinin mevcut yapı ile temel seviyesindeki bağlantısı nasıl sağlanmaktadır? Yeni temel veya kazıklara ihtiyaç olacak mıdır?

Cevap : Prensip olarak, mevcut yapının temel kirişleri ile MaSTER FRAME çerçevesinin temel kirişleri birbirine bağlanmaktadır. Gerekli görülmesi durumunda, kazık ihtiyacı olabileceği gibi, temelin güçlendirilmesi gibi uygulamalar da sözkonusu olabilmektedir.

12. Soru : Bu sistem planda simetrik olmayan yapılarda (örneğin planda L şeklindeki okullarda) uygulanabilir mi?

Cevap : Sözkonusu çerçevenin uygulanabileceği bir yapıysa bu tür okullara uygulanması mümkün olabilmektedir.

13. Soru : MF çerçevesi, ön ve arka olmak üzere yapının her iki cephesine uygulanması mı gerekmektedir? Planda X ve Y doğrultusundan her iki yöne uygulama da mümkün müdür?

Cevap : Çerçeve, genellikle, ön ve arka cepheye uygulanmaktadır. Ön cephede MaSTER FRAME çerçeve ile güçlendirme, arka cephede ise çelik çaprazlar ile veya farklı bir yöntemle güçlendirme de mümkündür. Ayrıca, X ve Y doğrultusunda her iki yönde MF çerçeve ile güçlendirme de mümkün olduğu gibi, bir doğrultuda konvansiyonel perde-duvar ile güçlendirme de mümkündür.

14. Soru : Tek bir doğrultuda MF çerçeve uygulandığında, deprem esnasındaki burulma nasıl önlenmektedir?

Cevap : Burulmanın meydana gelmemesi için çerçeveler çok dengeli olarak yerleştirilecek şekilde tasarım yapılmaktadır. Türkiye'deki mevcut deprem yönetmeliğine uygun şekilde perde-duvar ile kombinasyon da mümkündür.

15. Soru : Performans düzeyleri açısından bakıldığında, "Hemen Kullanım" (I.O.) ve "Can Güvenliği" (L.S.) seviyeleri mevcut olup, MaSTER FRAME bu seviyeleri nasıl karşılamaktadır?

Cevap : Türk Deprem Yönetmeliği'nde belirlenen "Hemen Kullanım" ve "Can Güvenliği" performans seviyelerini karşılayacak tasarım mümkündür.

16. Soru : Türkiye'de özellikle kamuya ait eğitim kurumlarında beton mukavemetinin düşük olduğu okullar mevcuttur. MF'in uygulanabileceği en düşük beton mukavemeti değeri nedir?

Cevap : Beton mukavemeti 8 N/mm^2 (8 MPa) üzeri olan yapılarda uygulama mümkün olmaktadır.

17. Soru : MaSTER Disk-Ankraj™ ile konvansiyonel ankraj (kimyasal ankraj) arasında ne gibi farklar vardır?

Cevap 1 : MaSTER Disk-Ankraj™'ın disk şeklindeki başlık bölümü konvansiyel ankraja göre oldukça yüksek kesme kuvvetini almakta, böylelikle konvansiyonel ankrajlara göre Disk-ankrajda montaj yapılacak ankraj derinliği kısalmaktadır. Özetle, Disk-ankraj kullanımında, mevcut yapısal elemanlarda bulunan donatıların yol açtığı sorunlar büyük ölçüde azalmaktadır.

Cevap 2 : MaSTER Disk-Ankraj™ 'ın kesme kuvvetinin konvansiyonel ankrajlara göre yüksek olması sebebi ile, uygulama için gerekli olan ankraj sayısı oldukça düşmekte (ankraj sayısı 1/2 ile 1/3 oranına düşmektedir), yapısal elemanlara uygulanan pürüzlendirme işlemine gerek kalmamakta, montaj esnasında meydana gelen ses, toz, titreşim, konvansiyonel yöntemlere göre gözle görülür bir şekilde azalmaktadır.

Cevap 3 : MaSTER Disk-Ankraj™ montajı, özel uçlu karot matkap ile delik açarak, epoksi ile sabitleme şeklindedir.

18. Soru : Türkiye'de mevcut yapılarda döşeme kalınlığı genellikle 10 cm civarında olup, dışarıdan güçlendirme yöntemi ile sonuç alınabilmekte midir?

Cevap : Döşeme kalınlığı 10 cm ise MASTER FRAME yöntemi uygulanabilmektedir.

19. Soru : Türkiye'de beton paspayı az olup, Disk-ankraj montajında sorun yaşanır mı?

Cevap : Disk-ankraj'ın disk bölümü montajında gerekli olan oyuk için 20 mm paya gerek vardır.

20. Soru : Maliyet ile ilgili bilgi mevcut mudur?

Cevap : Maliyet ile ilgili rapor hazırlama aşamasındayız. Yapı dışına uygulanacak çerçeve, normal betonarme çerçeve olup, özel malzeme olarak sadece MaSTER Disk-Ankraj™ kullanılmaktadır. Kullanılacak ankraj sayısı oldukça azalmakta, yapının içine girme ihtiyacı olmaması durumunda, işe/eğitime belirli bir süre ara verme veya başka bir binaya taşınma sebebi ile meydana gelecek maliyetlere gerek kalmamaktadır.

Ayrıca, iç mekanda güçlendirme çalışması yapılmaması, iç mimari onarımlara gereksinimi ortadan kaldırmaktadır. Bu sebeple, halihazırdaki konvansiyonel güçlendirme yöntemleri ile karşılaştırıldığında maliyet açısından kolaylıkla rekabet edebileceği beklentisi öngörülmektedir. Maliyet dışında, yapının kullanımının devam edebiliyor olmasının başlı başlına bir önem arz ettiğini düşünmekteyiz.

21. Soru :Bu güçlendirme sisteminin mühendislik ve tasarımının iyi anlaşılması da önemli olmakla birlikte, uygulamanın doğru ve hassas yapılıp yapılamayacağı hususu da önemli değil midir?

Cevap :Uygulamayı yapacak inşaat firmalarına uygulama eğitimi verebileceğimiz bir mekanizma planlamaktayız.

22. Soru : Isı yalıtımı ile ilgili bilgi verir misiniz?

Cevap : Dış duvarlarda ısı yalıtımı mevcut olduğu durumlarda, MaSTER FRAME^{TM} çerçevenin montaj yapılacağı bölgelerdeki yalıtım sökülüp, çerçeve uygulamasından sonra tekrar ısı yalıtımı yapılmalıdır.

23. Soru : Yapı hesap yöntemleri için özel bir programa ihtiyaç var mıdır?

Cevap : MaSTER FRAME^{TM} yöntemi hesapları için özel bir programa gerek yoktur.

Maeda Corporation/GKMC İnşaat ve Danışmanlık A.Ş

「MaSTER FRAME構法」 活用実績(前田建設担当分)

2018年6月

施工実績

No.	段階	設計	施工	物件名(工事名称)	施工年度	場所	採用規模・活用内容
1	竣工	前田	前田	三田松聖高等学校耐震補強工事	H22年度	兵庫県三田市	直付，柱PCa梁現場打ち 1階10構面、2階6構面 合計16構面
2	竣工	前田	前田	市川市立第八中学校校舎耐震補強工事	H22年度	千葉県市川市	直付，1階柱～PCa 1階～3階×6構面 合計18構面
3	竣工	前田	前田	市川市立大洲中学校校舎耐震補強工事	H22年度	千葉県市川市	直付，2階柱～PCa 1階～3階×4構面 合計12構面
4	竣工	前田	前田	石原産業㈱中央研究所2号棟耐震補強工事	H22年度	滋賀県草津市	直付，現場打ち 南面1階5構面、2階3構面 西面1階～2階4構面 合計16構面
5	竣工	日本工房(前田建築事務所)	藤建設(前田)	船泊中学校校舎棟耐震改修	H24年度	北海道礼文郡	直付，現場打ち 1階7構面、2階1構面 合計8構面
6	竣工	廣陌	砂原組	可部小学校校舎耐震改修(2-2棟)	H24～25年度	広島県広島市	直付，柱PCa梁現場打ち 1階26構面、2階21構面、3階15構面 合計62構面
7	竣工	廣陌	砂原組	可部小学校校舎耐震改修(1-4棟)	H24～25年度	広島県広島市	直付，現場打ち 1階8構面、2階4構面 合計12構面
8	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(本館A棟)	H24～25年度	宮城県仙台市	直付、間柱，現場打ち 1階6構面、2階4構面、3階～4階2構面 合計14構面
9	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(本館B棟)	H24～25年度	宮城県仙台市	直付、間柱，現場打ち 1階～2階4構面、3階2構面 合計10構面
10	竣工	日本郵政㈱	前田	郵便局(株)東北郵政研修センター改修(寄宿舎棟1)	H24～25年度	宮城県仙台市	直付、間柱，現場打ち 1階～2階7構面、3階5構面、4階3構面 合計22構面
11	竣工	前田	前田	関西ペイント尼崎事業所事務本館耐震工事	H25年度	兵庫県尼崎市	直付，現場打ち 1階～2階3構面、3階1構面 合計7構面
12	竣工	日本工房(前田建築事務所)	藤建設(前田)	礼文町立香深(カフカ)中学校校舎耐震改修	H25年度	北海道礼文郡	直付，現場打ち 1階5構面、2階3構面 合計8構面
13	竣工	前田建築事務所	東海興業	姫島青風寮耐震改修	H25年度	愛知県東海市	増設，現場打ち 1階～2階3構面 合計6構面
14	竣工	味の素エンジ(前田)	前田	味の素東海事業所厚生館	H25年度	三重県四日市市	直付，現場打ち 1階2構面 合計2構面
15	竣工	久米設計(前田建築事務所)	前田	北海道大学総合研究棟(薬学系)	H26年度	北海道札幌市	直付、間柱，現場打ち 南面_1階～3階7構面、4階5構面、5階2構面 北面_1階～3階9構面、4階～5階5構面 合計65構面
16	竣工	味の素エンジ(前田)	前田	味の素東海事業所本事務所棟	H26年度	三重県四日市市	直付，現場打ち 1階6構面、2階4構面 合計10構面
17	竣工	アーバンクリエイト	安藤・ハザマ	東都銀座ビル	H26年度	東京都中央区	直付，現場打ち 1階1構面 合計1構面
18	竣工	前田	FBS	シャルトル聖パウロ修道女会八代修道院	H27年度	熊本県八代市	増設，現場打ち 1階4構面 合計4構面
19	竣工	前田	前田	川崎穴水ビル事務所棟	H27年度	神奈川県川崎市	直付，現場打ち 1階2構面 合計2構面
20	竣工	東洋設計(山田構造デザイン)	FBS	食糧学院第2校舎	H27年度	東京都世田谷区	直付，現場打ち 1階～2階6構面、3階5構面 合計17構面
21	竣工	東洋設計(山田構造デザイン)	FBS	食糧学院第3校舎	H27年度	東京都世田谷区	直付，現場打ち 1階4構面、2階1構面 合計5構面
22	竣工	日本工房(前田建築事務所)	若狭組・亀田工業JV(前田)	上ノ国町役場庁舎	H28年度	北海道檜山郡	直付、間柱，場所打ち X方向_1階6構面、Y方向_1階4構面 合計10構面
23	竣工	宇田川設計	丸高工業	朝日野方マンション	H28年度	東京都中野区	直付，現場打ち 1階～2階2構面、3階～4階1構面 合計6構面
24	竣工	日本工房(前田建築事務所)	高木・川瀬軽常建設JV(前田)	木古内町産業会館	H29年度	北海道上磯郡	直付，現場打ち 1階～2階5構面、3階3構面 合計13構面
	竣工						

予定

No.	段階	設計	施工	物件名(工事名称)	施工年度	場所	採用規模・活用内容
1	設計中	前田建築事務所	未定	苫前町役場	未定	北海道苫前町	耐震補強評定 対応中（提案中） 構面数未定

「MaSTER FRAME構法」 活用実績（東洋建設担当分）

2018年6月

施工実績

No.	段階	設計	施工	物件名（工事名称）	施工年度	場所	採用規模・活用内容
1	竣工	中神設計	東洋	豊橋技術科学大学 高師住宅1号棟耐震改修工事	H22年度	愛知県豊橋市	直付，現場打ち 1階4構面、2階～3階2構面 合計8構面
2	竣工	古居構造設計	東洋	旭テック㈱ 市田寮耐震補強工事	H23年度	愛知県豊橋市	直付，現場打ち 1階6構面、2階4構面 合計10構面
3	竣工	中神設計	藤代建設	豊橋技術科学大学 第2期 No.1	H23年度	愛知県豊橋市	直付，現場打ち 1階4構面、2階～3階2構面 合計8構面
4	竣工	中神設計	藤代建設	豊橋技術科学大学 第2期 No.2	H23年度	愛知県豊橋市	直付，現場打ち 1階4構面、2階～3階2構面 合計8構面
5	竣工	中神設計	藤代建設	豊橋技術科学大学 第2期 No.3	H23年度	愛知県豊橋市	直付，現場打ち 1階4構面、2階～3階2構面 合計8構面
6	竣工	中神設計	藤代建設	豊橋技術科学大学 第2期 No.4	H23年度	愛知県豊橋市	直付，現場打ち 1階4構面、2階～3階2構面 合計8構面
7	竣工	古居構造設計	白鳥工務店	春日井市立 柏原中学校耐震補強工事	H24年度	愛知県春日井市	直付，現場打ち 1階～2階4構面 合計8構面
8	竣工	古居構造設計	近藤組	近藤組本社ビル耐震補強工事	H24年度	愛知県刈谷市	直付，現場打ち 1階2構面、2階1構面、3階1構面 合計4構面
9	竣工	伊藤構造技術研究所	ファーストカルデア	コンド瀬田耐震補強工事	H26年度	東京都世田谷区	増設，現場打ち 1～4階2構面、5･6階1構面 合計10構面
10	竣工	㈱マルタ設計	東洋建設	林野庁東宮1号宿舎耐震補強工事	H29年度	東京都江東区	直付，PCa 合計3構面

予定

No.	段階	設計	施工	物件名（工事名称）	工期	場所	採用規模・活用内容
1	発注待ち	TDS	東建サービス（予定）	GSハイム目白耐震補強工事	設計完了 着工時期未定	東京都新宿区	増設， 合計6構面

MaSTER FRAME Technology Transfer Works Outline

Presented by Dr. Fatih Sütcü on behalf of İTÜ team. 2018.11.05 Tokyo-Japan

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

2# Task Force (TF)

Team:
- ITU
    - Fatih Sutcu
    - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

Objective:

MF retrofit modelling and analysis for single frame following MF guideline tests.

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- Guideline report

3# DA Tests:

Team:
- ITU
    - Fatih Sutcu
    - Valery Piva
- ITU labs technicians
- Maeda Corp
- GKMC
- Garanti Koza

Objective:

Testing and confirming the shear and residual drawing resistance of Disc Anchors in ITU Structural and Earthquake Engineering Labs by using low strength concrete.
Several embedment depth of DA is used in tests.

Output:
- Test approval report from ITU

4# Academic Studies:

Team:
- ITU
    - Fatih Sutcu (Adviser)
    - Zeynep Deger (Adviser)
    - Valery Piva
    - Omer Hattapoglu
    - Egemen Turan
- TUBITAK
- MNE

Objective:

Master thesis of graduate students about comprehensive research on DA and MF.

International journal and conference papers.

TUBITAK (Turkish Science Promotion Council) grant is a prestigious research support.

Output:
- Master thesis
- Journal and Conference papers
- Research grant

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

PROMER
Müşavirlik Mühendislik Ltd. Şti.
Consultancy Engineering Ltd Co.

İPKB

REPUBLIC OF TURKEY
ISTANBUL SPECIAL PROVINCIAL ADMINISTRATION
ISTANBUL PROJECT COORDINATION UNIT

RETROFITTING A TYPICAL SCHOOL BUILDING
USING MASTER FRAME® TECHNIQUE
İSTANBUL

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

Figure-2a.Architectural Plans (Ground Floor)

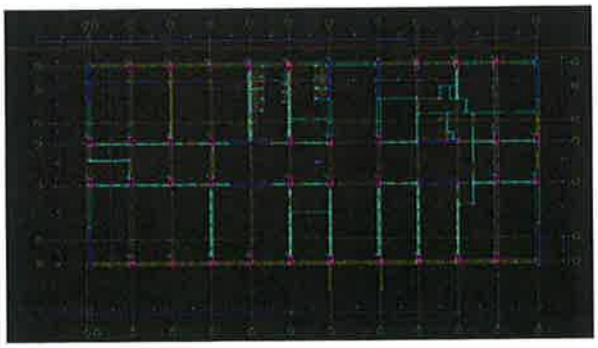
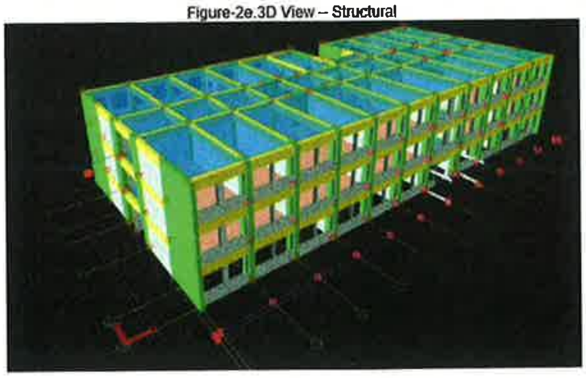


Figure-2e.3D View – Structural



Topic	Value
Existing concrete grade	C15
Existing rebar grade	STI
Existing rebar corrosion level	Low
Concrete class of New elements	C30
Steel grade for new elements	STIII
Soil Type	CLAY
Local soil class	Z3
Soil group	C
Soil bearing capacity	100 kN/m²
Modulus of subgrade reaction	15000 kN/m³
Soil improvement was not applied.	

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

Figure-5c. 3D view of Conventional Retrofitting

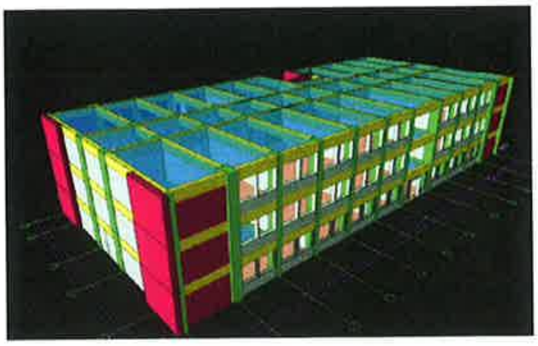
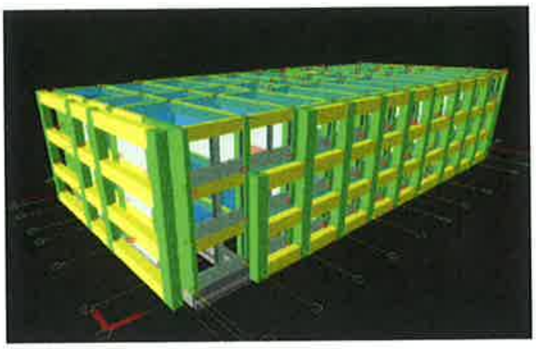


Figure-5d. 3D View of Master Frame® Retrofitting



Performance and cost comparison

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

2# Task Force (TF)

Team:
- ITU
  - Fatih Sutcu
  - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

Objective:

MF retrofit modelling and analysis for single frame following MF guideline tests.

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- Guideline report

3# DA Tests:

Team:
- ITU
  - Fatih Sutcu
  - Valery Piva
- ITU labs technicians
- Maeda Corp
- GKMC
- Garanti Koza

Objective:

Testing and confirming the shear and residual drawing resistance of Disc Anchors in ITU Structural and Earthquake Engineering Labs by using low strength concrete.

Several embedment depth of DA is used in tests.

Output:
- Test approval report from ITU

4# Academic Studies:

Team:
- ITU
  - Fatih Sutcu (Adviser)
  - Zeynep Deger (Adviser)
  - Valery Piva
  - Omer Hattapoglu
  - Egemen Turan
- TUBITAK
- MNE

Objective:

Master thesis of graduate students about comprehensive research on DA and MF.

International journal and conference papers.

TUBITAK (Turkish Science Promotion Council) grant is a prestigious research support.

Output:
- Master thesis
- Journal and Conference papers
- Research grant

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

2# Task Force (TF)

Team:
- ITU
  - Fatih Sutcu
  - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

Objective:
MF retrofit modelling and analysis for single frame following MF guideline tests.

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- Guideline report

3# DA Tests:

Team:
- ITU
  - Fatih Sutcu
  - Valery Piva
- ITU labs technicians
- Maeda Corp
- GKMC
- Garanti Koza

Objective:
Testing and confirming the shear and residual drawing resistance of Disc Anchors in ITU Structural and Earthquake Engineering Labs by using low strength concrete.
Several embedment depth of DA is used in tests.

Output:
- Test approval report from ITU

4# Academic Studies:

Team:
- ITU
  - Fatih Sutcu (Adviser)
  - Zeynep Deger (Adviser)
  - Valery Piva
  - Omer Hattapoglu
  - Egemen Turan
- TUBITAK
- MNE

Objective:
Master thesis of graduate students about comprehensive research on DA and MF.

International journal and conference papers.

TUBITAK (Turkish Science Promotion Council) grant is a prestigious research support.

Output:
- Master thesis
- Journal and Conference papers
- Research grant

MaSTER FRAME Technology Transfer Works Outline

2# Task Force (TF)

Team:
- ITU
  - Fatih Sutcu
  - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

Objective:
MF retrofit analysis for following MF (

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- Guideline report

fit design and analysis of 3 and 4 story school
ng models with and without shear walls

MaSTER FRAME Technology Transfer Works Outline

2# Task Force (TF)

Team:
- ITU
  - Fatih Sutcu
  - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

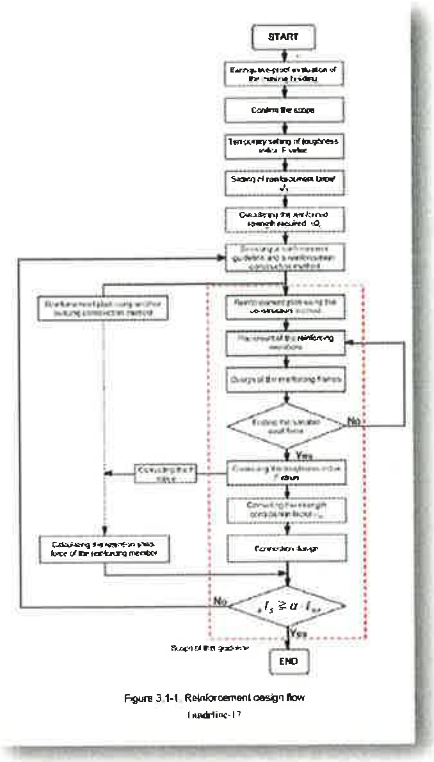
Objective:

MF retrofit modelling and analysis for single frame following MF guideline tests.

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- **Guideline report**



A MaSTER FRAME retrofit design guideline will be prepared according to the Turkish Seismic Code

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

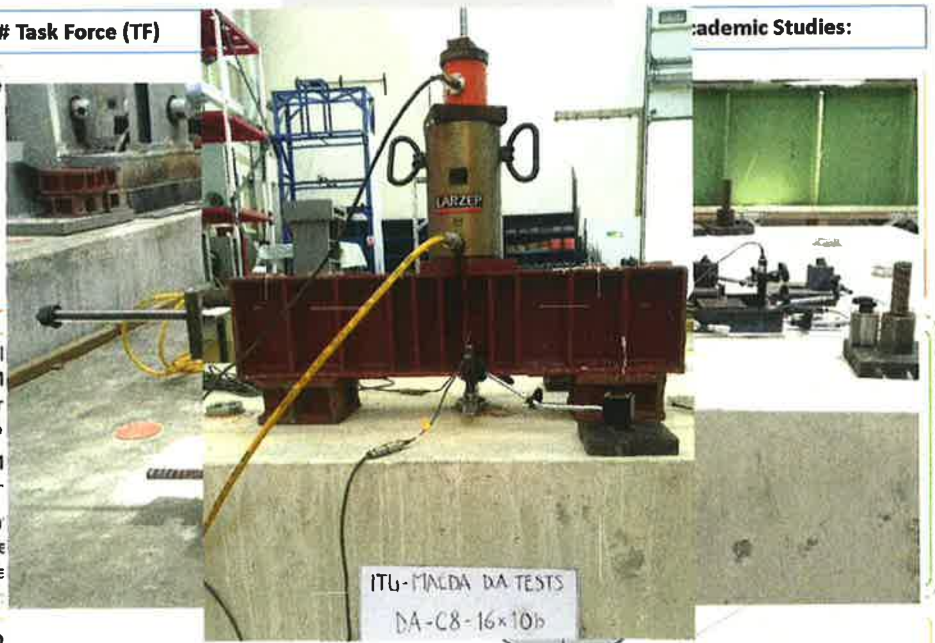
Output:
- Letter of brief comments by ITU

2# Task Force (TF)

Te
•
•
•
•
•

Ol
M
ar
fo
M
lir
In
de
Se

O
•
•



PuShear Tests of Disc Anchors

:ademic Studies:

papers
- Research grant

MaSTER FRAME Technology Transfer Works Outline

1# Analysis for IPCU

Team:
- Promer
- Maeda Corp
- GKMC

Objective:
- Selecting example building
- MF retrofit design with linear modal analysis.
- Searching an economical and effective design / application method for MF according to Turkish Seismic Code

Output:
- Letter of brief comments by ITU

2# Task Force (TF)

Team:
- ITU
  - Fatih Sutcu
  - Zeynep Deger
- Promer
- MEU
- Maeda Corp + GKMC +Garanti Koza
- Miyamoto

Objective:
MF retrofit modelling and analysis for single frame following MF guideline tests.

MF retrofit design with non-linear push-over and THA.

Investigating the MF retrofit in detail according to Turkish Seismic Code

Output:
- TF report from ITU
- Guideline report

3# DA Tests:

Team:
- ITU
  - Fatih Sutcu
  - Valery Piva
- ITU labs technicians
- Maeda Corp
- GKMC
- Garanti Koza

Objective:
Testing and confirming the shear and residual drawing resistance of Disc Anchors in ITU Structural and Earthquake Engineering Labs by using low strength concrete.
Several embedment depth of DA is used in tests.

Output:
- Test approval report from ITU

4# Academic Studies:

Team:
- ITU
  - Fatih Sutcu (Adviser)
  - Zeynep Deger (Adviser)
  - Valery Piva
  - Omer Hattapoglu
  - Egemen Turan
- TUBITAK
- MNE

Objective:
Master thesis of graduate students about comprehensive research on DA and MF.

International journal and conference papers.

TUBITAK (Turkish Science Promotion Council) grant is a prestigious research support.

Output:
- Master thesis
- Journal and Conference papers
- Research grant

MaSTER FRAME Technology Transfer Works Outline

4# Academic Studies:

Team:
- ITU
  - Fatih Sutcu (Adviser)
  - Zeynep Deger (Adviser)
  - Valery Piva
  - Omer Hattapoglu
  - Egemen Turan
- TUBITAK
- MNE

Objective:
Master thesis of graduate students about comprehensive research on DA and MF.

International journal and conference papers.

TUBITAK (Turkish Science Promotion Council) grant is a prestigious research support.

Output:
- Master thesis
- Journal and Conference papers
- Research grant

İTÜ

TÜBİTAK

Thank you for your attention

RETROFITTING OF A TYPICAL SCHOOL BUILDING USING MaSTER FRAME

you name it. we engineer it.

2018

ProMer Müşavirlik Mühendislik A.Ş.
Consultancy Engineering Inc.

Merkezi Ofis // Head Office:
Mutlukent Mah. 1966. Cadde, 1967. Sokak, No.14
06800 Ümitköy, Ankara/Turkey
Tel: +(90) 312 235 79 00 (pbx)
Fax: +(90) 312 235 76 31
Koordinat: N.+39°53'56.04, E:+32°42'33.20

İstanbul Ofis // İstanbul Office:
Küçükbakkalköy Mah. Kayışdağı Cad.
Ayşe Hatun Çeşme Sok. No.2 D.9-10
34750 Ataşehir, İstanbul/Turkey
Tel: +(90) 216 576 65 12-15 • Fax: +(90) 216 576 59 56
Koordinat: N:+40°58'45.78, E:+29°6'34.35

www.promerengineering.com.tr • info@promerengineering.com.tr

RETROFITTING OF A TYPICAL SCHOOL BUILDING USING MaSTER FRAME© PRESENTATION CONTENT

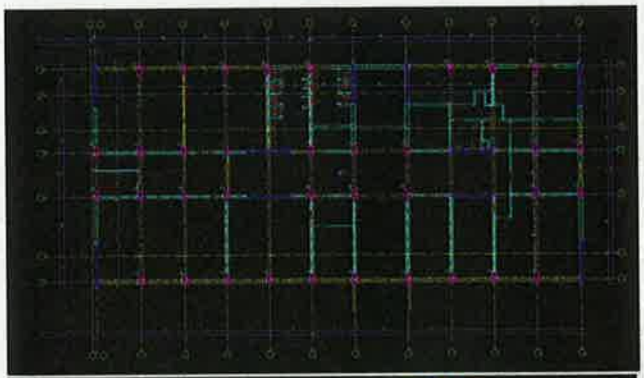
- 4 Storey typical school building assessment, Static non-linear pushover /
  4 Katlı tipik okul binası mevcut durum analizi Statik, sabit modlu, doğrusal olmayan itme yöntemi

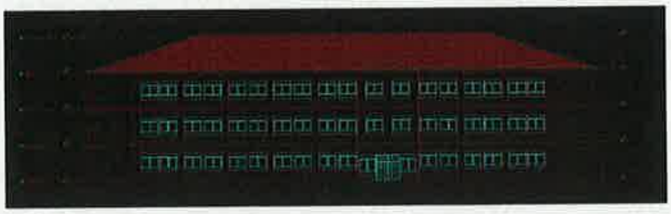
- Time history and static pushover analysis of retrofitted (using MaSTER FRAME and DA)of 4 storey typical school building / *4 katlı tipik okul binası MaSTER FRAME © ve Disk Ankraj kullanılarak güçlendirme çalışması ve güçlendirilmiş yapının statik itme yöntemi ve 7 deprem kullanılarak zaman tanım alanında analiz yöntemleri ile değerlendirilmesi*

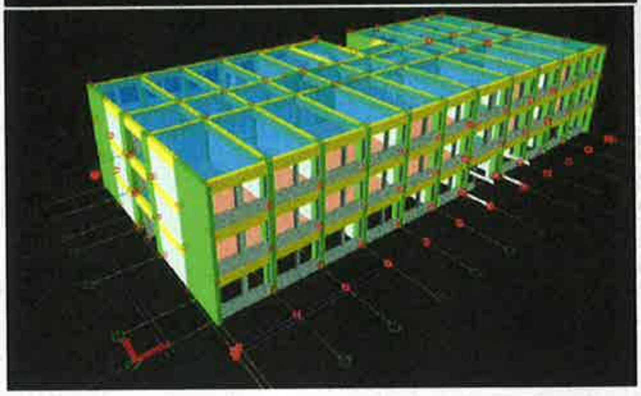
- 3 storey typical school building assessment, static non-linear pushover / *3 Katlı tipik okul binası mevcut durum analizi Statik, sabit modlu, doğrusal olmayan itme yöntemi*

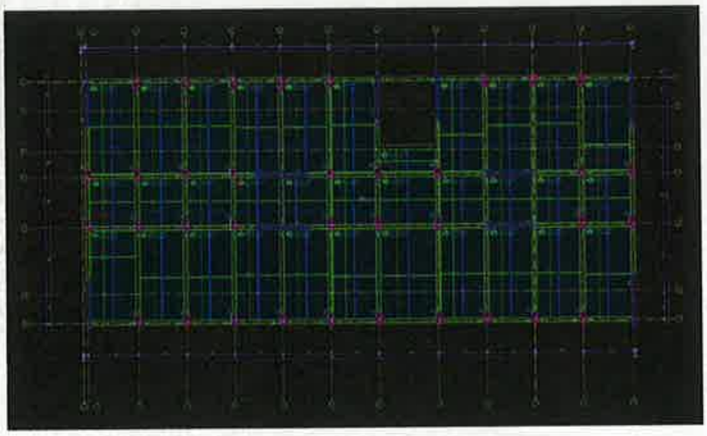
- Time history and static pushover analysis of retrofitted (using MaSTER FRAME and DA) of 3 storey typical school building / *3 katlı tipik okul binası MaSTER FRAME © ve Disk Ankraj kullanılarak güçlendirme çalışması ve güçlendirilmiş yapının statik itme yöntemi ve 7 deprem kullanılarak zaman tanım alanında analiz yöntemleri ile değerlendirilmesi*

TYPICAL SCHOOL BUILDING









EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALL / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

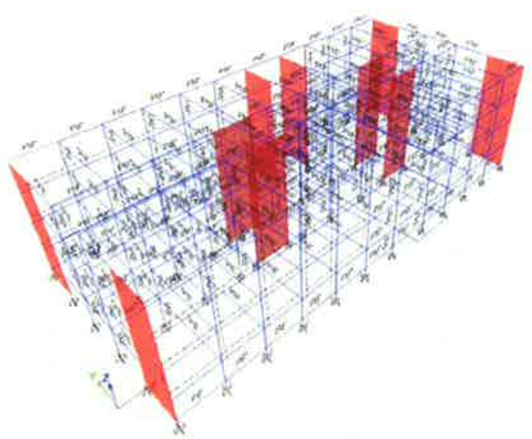
- Typical school building / *Tipik Okul Binası*
- C15.0 Mpa, STIII, Construction Date / *Yapım Yılı*: before 2000 *öncesi*, Soil / *Zemin* Z3 C
- Earthquake Zone / *Deprem Bölgesi* I.
- Live load participation factor / *Hareketli Yük Katılım Katsayısı*: 0.60
- Floor loads / *Döşeme Yükleri*: G=0.212 t/m2, Q=0.350 t/m2
- Roof loads / Çatı katı Yükleri: G=0.149 t/m2, Q=0.225 t/m2
- Wall weight / *Duvar Ağırlığı* 0.39 t/m2
- Structure type/*Yapı Tipi*: Reinforced Concrete Frame–Shear Wall/Betonarme Çerçeve + BA Perde
- Foundation Type / *Temel Tipi*: *Continuous Footing* / Sürekli Temel
- Proposed Performance / *Öngörülen Performans*: Immediate Occupancy performance for earthquake with probability of 10 % in 50 years / *50 yılda aşılma olasılığı % 10 olan depremde Hemen Kullanım*

Kat Bilgileri:

İsim	No	Yükseklik (m)	Alan(m2)
Zemin Kat	1	2,9	760
1. Kat	2	2,9	760
2. Kat	3	2,9	760
3. Kat	4	2,9	760

EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Structure is modelled in ETAPS ver 16 using frame members with plastic joint and shear walls with fiber modeling /
- *Kolon ve kirişlerde yığılı plastik mafsallı doğrusal olmayan modelleme kullanılmıştır.*
- *Perdeler için fiber modelleme yöntemi kullanılmıştır.*



- 3D ETABS modeli

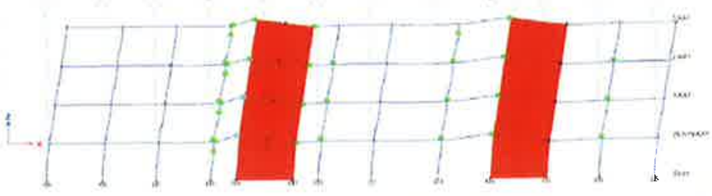
EXISTING 4 STOREY BUILDING INFORMATION WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Existing building is performed a static non-linear pushover analysis in ETAPS software / *Mevcut Bina Performans Analizi için ETABS analiz proğramı kullanılarak doğrusal olmayan sabit modlu itme analizi yapılmıştır.*
- Target displacement is calculated as per TEC 2007 7C and 7D and a static non-nonlinear pushover analysis is performed up to calculated target displacement. / DBYBHY 2007 bölüm 7C ve 7D'ye göre hedef deplasmanları hesaplanmış ve hedef deplasmana kadar yapılan ikinci bir itme ile performans durumu tespit edilmiştir.

Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	hedef deplasman (m) uxN1
0,41	2,5	9,81	1	0,041	3,4137	2,8736	1,3115	0,0537	0,074

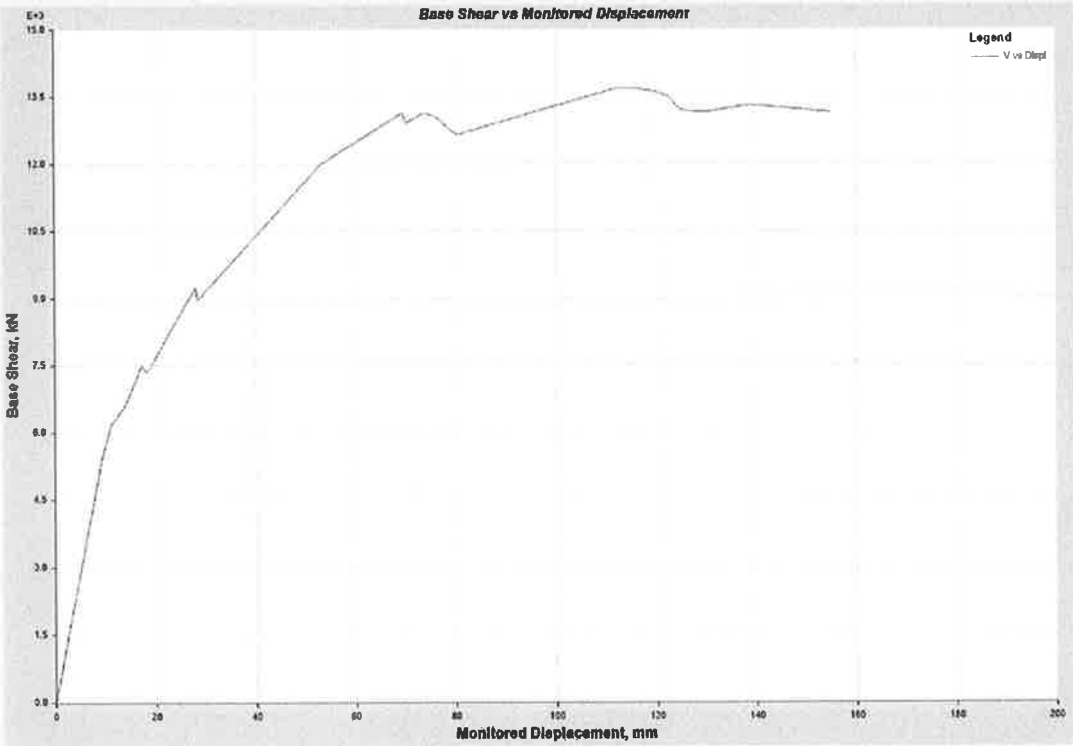
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0,38	2,5	9,81	1	0,036	4,4379	2,2104	1,3170	0,0472	0,065

- Fiber Model PushX –
- D Aksı Hedef Deplasman için Mafsal Oluşumu



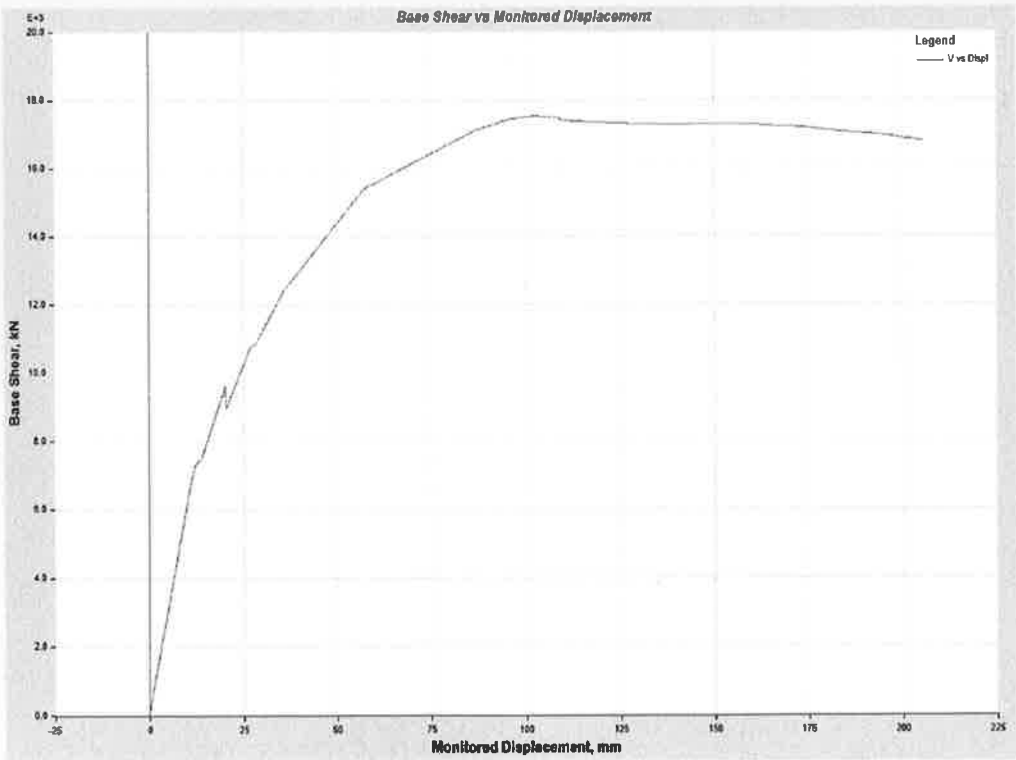
EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Pushover Curve X direction / *X yönü İtme analizleri sonucu elde edilen etkiler*



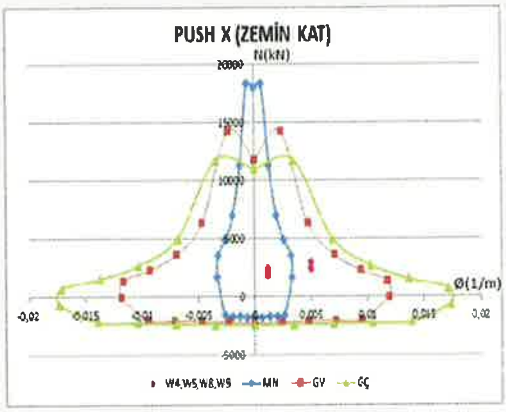
EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Y direction Push over curve / *Y direction itme analizleri sonucu elde edilen etkiler*

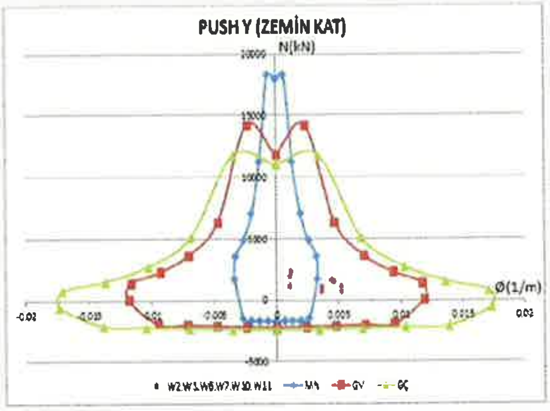


EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Axial load-curvature relationships are optained for every column type and for every damage levels using XTRACT / *Her bir kolon tipi için XTRACT yazılımı kullanılarak Eksenel yük eğrilik grafikleri her bir hasar sınırı için elde edilmiştir.*
- Axial load-curvature values calculated from pushover –target displacement analysis were placed in the graphs to see damage levels / *Hedef deplasmana kadar yapılan itme sonucunda her bir kolon/perde için elde edilen eksenel yük –eğrilik değerleri hasar sınırı eğrilerine oturtularak hasar durumları listelenmiştir.*



- Shear Walls X direction ground floor / *Mevcut Perdeler X yönü, Zemin Kat Hasar Durumu*



- Shear Walls Y direction ground floor / *Mevcut Perdeler Y yönü, Zemin Kat Hasar Durumu*

EXISTING BUILDING INFORMATION – 4 STOREY WITH SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDELİ 4 KATLI*

- Summary Table / Tablolaştırılan sonuçlardan: 50 yılda olma olasılığı % 10 olan Tasarım depreminde minimum hasar seviyesinde olması gereken elemanların belirgin ve ileri hasar seviyesinde olduğu görülmektedir.
- Buildings does not meet TEC 2007 and needs retrofitting / *Yapı DBYBHY 2007'yi sağlamadığı için güçlendirme ihtiyacı vardır.*

PUSH X

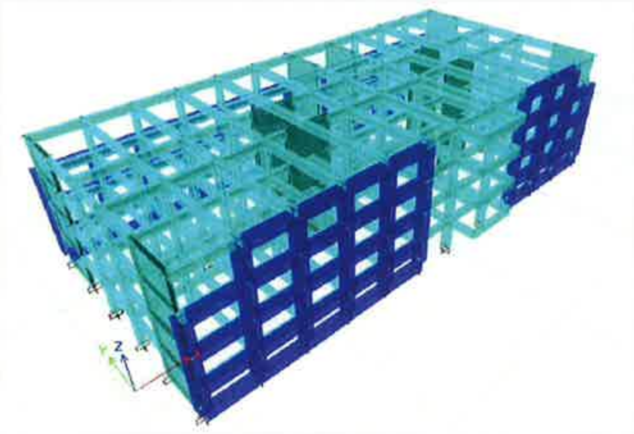
	KOLON						KİRİŞ						PERDE					
	MİN HASAR		BELİRGİN HASAR		İLERİ HASAR		MİN HASAR		BELİRGİN HASAR		İLERİ HASAR		MİN HASAR		BELİRGİN HASAR		İLERİ HASAR	
3.KAT	20\36	56%	10\36	28%	-	0%	36/44	82%	4\44	9%	4\44	9%	4\4	100%	-	0%	-	0%
2.KAT	32\36	89%	4\36	11%	-	0%	31/44	70%	9\44	20%	4\44	9%	4\4	100%	-	0%	-	0%
1.KAT	32\36	89%	4\36	11%	-	0%	31/44	70%	9\44	20%	4\44	9%	4\4	100%	-	0%	-	0%
ZEMİN KAT	34\36	94%	2\36	6%	-	0%	36/44	82%	4\44	9%	4\44	9%	-	0%	4\4	100%	-	0%

PUSH Y

	KOLON						KİRİŞ						PERDE					
	MİN HASAR		BELİRGİN HASAR		İLERİ HASAR		MİN HASAR		BELİRGİN HASAR		İLERİ HASAR		MİN HASAR		BELİRGİN HASAR		İLERİ HASAR	
3.KAT	36\36	100%	-	0%	-	0%	31\38	82%	4\38	11%	3\38	8%	6\6	100%	-	0%	-	0%
2.KAT	36\36	100%	-	0%	-	0%	8\38	21%	27\38	71%	3\38	8%	6\6	100%	-	0%	-	0%
1.KAT	36\36	100%	-	0%	-	0%	8\38	21%	27\38	71%	3\38	8%	6\6	100%	-	0%	-	0%
ZEMİN KAT	36\36	100%	-	0%	-	0%	21\38	55%	14\38	37%	3\38	8%	-	0%	6\6	100%	-	0%

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

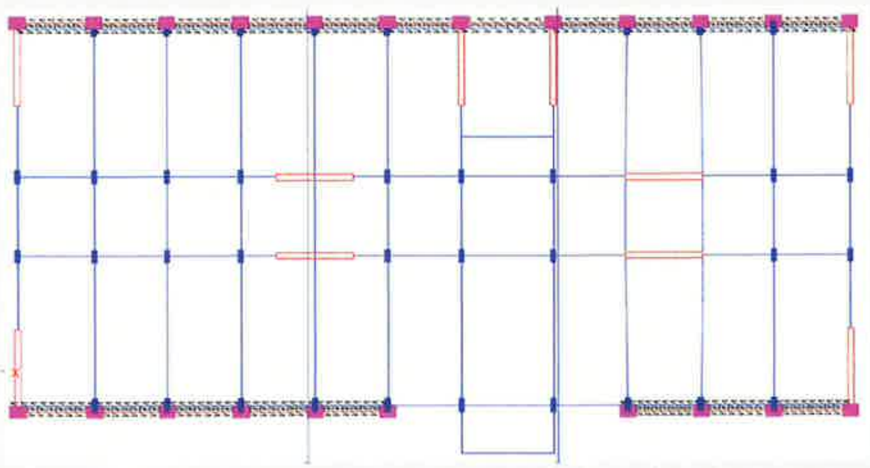
- MF application for 3 storey for back side / *Yapı arka cephesinde boylu boyunca ve 3 kat yüksekliğinde,*
- MF application in two pieces for 4 storey in front face / *Yapı ön cephesinde iki ayrı parça halinde 4 kat yüksekliğinde MF elemanları kullanılmıştır.*



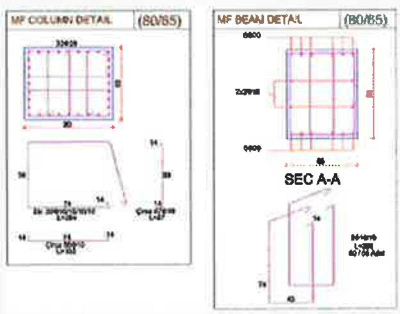
- MF Front face / *Ön Cephe MF yerleşimi*

- MF Back face / *Arka Cephe MF yerleşimi*

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*



- ETABS plan view / *ETABS Ankrajlı Plan Görünüş*



- MF frame member dimensions / MF eleman kesit ve donatıları

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

- Retrofitted building is performed assessment analysis the same method with existing one and seen as satisfying TEC 2007 / *Mevcut durum analizinde kullanılan aynı yöntemler ile hesaplanan hedef deplasmana kadar itilen itme analizi neticesinde yapılan performans analizinde yapı DBYBHY 2007 kriterlerini sağlar hale gelmiştir.*

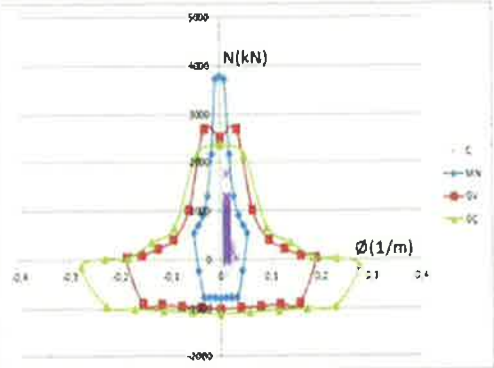
Γ_{x1}	Φ_{xN}	M_{xn}	$d_1^{(p)}$	u_{xN1}
53,83	0,026	3308,27	0,025412	0,035566
Γ_{y1}	Φ_{yN}	M_{yn}	$d_1^{(p)}$	u_{yN1}
53,98	0,026	3249,41	0,035586	0,049941

- Target Disp. /*X ve Y yönü hedef deplasmanları*

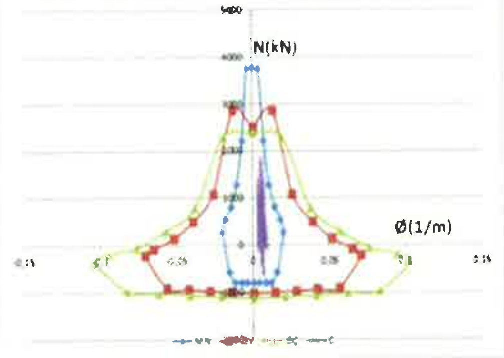
TABLE: Modal Participating Mass Ratios

Case	Mode	Period	UX	UY
		sec		
Modal	1	0,283	0,0003	0,7083
Modal	2	0,271	0,7374	0,0004
Modal	3	0,214	0,0014	0,007

- Retrofitted Build. Eff. Periods / *Güçlendirilmiş Yapı Etkin Periyodlar*



- Column Damage X dir. / *Kolon Hasar Durum X yönü*



- Column Damage Y dir. / *Kolon Hasar Durum Y yönü*

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

- Shear walls x dir. damage levels were seen as satisfying TEC 2007 / *Mevcut durum analizinde kullanılan aynı yöntemler ile hesaplanan hedef deplasmana kadar itilen itme analizi neticesinde yapılan performans analizinde yapı DBYBHY 2007 kriterlerini sağlar hale*

KAT	KOLON	MAX/MIN	MAFSAL	P	Pmutlak	R3Plastic	Lp	Φp	Φy	Φt	Minimum Hasar	Belirgin Hasar	İleri Hasar	Hasar Durumu
				KN	KN	Radians	m	1/m	1/m	1/m				
3.KAT	W1785	PUSHX Max	W1785H1	-373,384	373,3839	0,000043	1,9	2,26316E-05	0,0009	0,000923	İçinde	İçinde	İçinde	MH
3.KAT	W1785	PUSHX Min	W1785H1	-420,976	420,9756	-3E-06	1,9	1,57895E-06	0,0009	0,000902	İçinde	İçinde	İçinde	MH
3.KAT	W1786	PUSHX Max	W1786H1	-366,515	366,5154	0,00005	1,9	2,63158E-05	0,0009	0,000926	İçinde	İçinde	İçinde	MH
3.KAT	W1786	PUSHX Min	W1786H1	-401,807	401,8072	-6E-06	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
3.KAT	W8	PUSHX Max	W8H1	6,5646	-6,5646	0,000032	1,9	1,68421E-05	0,0009	0,000917	İçinde	İçinde	İçinde	MH
3.KAT	W8	PUSHX Min	W8H1	-238,207	238,2068	-1,2E-05	1,9	6,31579E-06	0,0009	0,000906	İçinde	İçinde	İçinde	MH
3.KAT	W9	PUSHX Max	W9H3	7,1097	-7,1097	0,00004	1,9	2,10526E-05	0,0009	0,000921	İçinde	İçinde	İçinde	MH
3.KAT	W9	PUSHX Min	W9H3	-232,606	232,6062	-0,00001	1,9	5,26316E-06	0,0009	0,000905	İçinde	İçinde	İçinde	MH
2.KAT	W1785	PUSHX Max	W1785H2	-870,158	870,1981	0,000048	1,9	2,52632E-05	0,0009	0,000925	İçinde	İçinde	İçinde	MH
2.KAT	W1785	PUSHX Min	W1785H2	-944,284	944,2844	-5,2E-05	1,9	2,73684E-05	0,0009	0,000927	İçinde	İçinde	İçinde	MH
2.KAT	W1786	PUSHX Max	W1786H2	-839,651	839,651	0,000058	1,9	3,05263E-05	0,0009	0,000931	İçinde	İçinde	İçinde	MH
2.KAT	W1786	PUSHX Min	W1786H2	-904,125	904,1251	-4,9E-05	1,9	2,57895E-05	0,0009	0,000926	İçinde	İçinde	İçinde	MH
2.KAT	W8	PUSHX Max	W8H2	-68,5729	68,5729	0,000051	1,9	2,68421E-05	0,0009	0,000927	İçinde	İçinde	İçinde	MH
2.KAT	W8	PUSHX Min	W8H2	-604,682	604,6815	-5,3E-05	1,9	2,78947E-05	0,0009	0,000928	İçinde	İçinde	İçinde	MH
2.KAT	W9	PUSHX Max	W9H4	-19,5458	19,5458	0,000061	1,9	3,21053E-05	0,0009	0,000932	İçinde	İçinde	İçinde	MH
2.KAT	W9	PUSHX Min	W9H4	-542,876	542,8758	-4,9E-05	1,9	2,57895E-05	0,0009	0,000926	İçinde	İçinde	İçinde	MH
1.KAT	W1785	PUSHX Max	W1785H3	-1362,27	1362,274	-7E-06	1,9	3,68421E-06	0,0009	0,000904	İçinde	İçinde	İçinde	MH
1.KAT	W1785	PUSHX Min	W1785H3	-1471,57	1471,574	-0,00016	1,9	8,36842E-05	0,0009	0,000984	İçinde	İçinde	İçinde	MH
1.KAT	W1786	PUSHX Max	W1786H3	-1308,39	1308,388	-7E-06	1,9	3,68421E-06	0,0009	0,000904	İçinde	İçinde	İçinde	MH
1.KAT	W1786	PUSHX Min	W1786H3	-1402,06	1402,064	-0,00016	1,9	8,15789E-05	0,0009	0,000982	İçinde	İçinde	İçinde	MH
1.KAT	W8	PUSHX Max	W8H3	-127,021	127,0209	0,000037	1,9	1,94737E-05	0,0009	0,000919	İçinde	İçinde	İçinde	MH
1.KAT	W8	PUSHX Min	W8H3	-962,219	962,2185	-0,00014	1,9	7,31579E-05	0,0009	0,000973	İçinde	İçinde	İçinde	MH
1.KAT	W9	PUSHX Max	W9H2	-32,0507	32,0507	0,000045	1,9	2,36842E-05	0,0009	0,000924	İçinde	İçinde	İçinde	MH
1.KAT	W9	PUSHX Min	W9H2	-845,842	845,8421	-0,00013	1,9	7,05263E-05	0,0009	0,000971	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W1785	PUSHX Max	W1785H4	-1848,26	1848,262	-7E-06	1,9	3,68421E-06	0,0009	0,000904	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W1785	PUSHX Min	W1785H4	-2214,55	2214,547	-0,00339	1,9	0,001783158	0,0009	0,002683	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W1786	PUSHX Max	W1786H4	-1769,11	1769,108	-8E-06	1,9	4,21053E-06	0,0009	0,000904	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W1786	PUSHX Min	W1786H4	-2111,23	2111,228	-0,00341	1,9	0,001792632	0,0009	0,002693	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W8	PUSHX Max	W8H4	-191,87	191,87	-9E-06	1,9	4,73684E-06	0,0009	0,000905	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W8	PUSHX Min	W8H4	-1301,55	1301,545	-0,00348	1,9	0,00183	0,0009	0,00273	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W9	PUSHX Max	W9H1	-51,9901	51,9901	-9E-06	1,9	4,73684E-06	0,0009	0,000905	İçinde	İçinde	İçinde	MH
ZEMIN KAT	W9	PUSHX Min	W9H1	-1133,97	1133,974	-0,0035	1,9	0,00184	0,0009	0,00274	İçinde	İçinde	İçinde	MH

Existing Shear Walls Damage levels X dir. / *Mevcut Perde Hasar Durumu X yönü*

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

- Shear walls y dir. damage levels were seen as satisfying TEC 2007 Mevcut durum analizinde kullanılan aynı yöntemler ile hesaplanan hedef deplasmana kadar itilen itme analizi neticesinde yapılan performans analizinde yapı DBYBHY 2007 kriterlerini sağlar hale gelmiştir.

KAT	KOLON	MAX/MIN	MAFSAL	P kN	|P|mutlak kN	KRPlastic Radians	Lp m	Φp 1/m	Φy 1/m	Φt 1/m	Minimum Hasar	Belirgin Hasar	İleri Hasar	Hasar Durumu
3.KAT	W1781	PUSHY Max	W1781H1	-94,545	94,545	0,00005	1,9	5,26316E-06	0,0009	0,000905	İçinde	İçinde	İçinde	MH
3.KAT	W1781	PUSHY Min	W1781H1	-241,017	241,017	-5,5E-05	1,9	2,09474E-05	0,0009	0,000929	İçinde	İçinde	İçinde	MH
3.KAT	W1782	PUSHY Max	W1782H1	6,3134	-6,3134	0,000009	1,9	4,73684E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
3.KAT	W1782	PUSHY Min	W1782H1	-95,5453	95,5453	-4,3E-05	1,9	2,26316E-05	0,0009	0,000923	İçinde	İçinde	İçinde	MH
3.KAT	W1787	PUSHY Max	W1787H1	-164,795	164,7957	0,000006	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
3.KAT	W1787	PUSHY Min	W1787H1	-300,955	300,9547	-4,5E-05	1,9	2,36842E-05	0,0009	0,000924	İçinde	İçinde	İçinde	MH
3.KAT	W1788	PUSHY Max	W1788H1	-162,236	162,2358	0,000006	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
3.KAT	W1788	PUSHY Min	W1788H1	-299,815	299,8152	-4,3E-05	1,9	2,26316E-05	0,0009	0,000923	İçinde	İçinde	İçinde	MH
3.KAT	W1789	PUSHY Max	W1789H1	-95,6824	95,6824	0,000007	1,9	3,68421E-06	0,0009	0,000904	İçinde	İçinde	İçinde	MH
3.KAT	W1789	PUSHY Min	W1789H1	-246,808	246,8027	-5,4E-05	1,9	2,84211E-05	0,0009	0,000928	İçinde	İçinde	İçinde	MH
3.KAT	W1790	PUSHY Max	W1790H1	5,0342	-5,0342	0,000012	1,9	6,31579E-06	0,0009	0,000906	İçinde	İçinde	İçinde	MH
3.KAT	W1790	PUSHY Min	W1790H1	-56,9264	56,9264	-2,6E-05	1,9	1,36842E-05	0,0009	0,000914	İçinde	İçinde	İçinde	MH
2.KAT	W1781	PUSHY Max	W1781H2	-245,558	245,5577	0,000046	1,9	2,42105E-05	0,0009	0,000924	İçinde	İçinde	İçinde	MH
2.KAT	W1781	PUSHY Min	W1781H2	-351,724	351,7238	-4,3E-05	1,9	2,26316E-05	0,0009	0,000923	İçinde	İçinde	İçinde	MH
2.KAT	W1782	PUSHY Max	W1782H2	-283,095	283,095	0,000046	1,9	2,42105E-05	0,0009	0,000924	İçinde	İçinde	İçinde	MH
2.KAT	W1782	PUSHY Min	W1782H2	-523,748	523,7482	2,5E-05	1,9	1,31579E-05	0,0009	0,000913	İçinde	İçinde	İçinde	MH
2.KAT	W1787	PUSHY Max	W1787H2	-467,539	467,5388	0,000042	1,9	2,21053E-05	0,0009	0,000922	İçinde	İçinde	İçinde	MH
2.KAT	W1787	PUSHY Min	W1787H2	-559,752	559,7523	-3,7E-05	1,9	1,94737E-05	0,0009	0,000919	İçinde	İçinde	İçinde	MH
2.KAT	W1788	PUSHY Max	W1788H2	-457,223	457,2229	0,000043	1,9	2,26316E-05	0,0009	0,000923	İçinde	İçinde	İçinde	MH
2.KAT	W1788	PUSHY Min	W1788H2	-549,324	549,3239	-3,5E-05	1,9	1,84211E-05	0,0009	0,000918	İçinde	İçinde	İçinde	MH
2.KAT	W1789	PUSHY Max	W1789H2	-289,423	289,4229	0,000046	1,9	2,42105E-05	0,0009	0,000924	İçinde	İçinde	İçinde	MH
2.KAT	W1789	PUSHY Min	W1789H2	-386,499	386,4986	-2,9E-05	1,9	1,52632E-05	0,0009	0,000915	İçinde	İçinde	İçinde	MH
2.KAT	W1790	PUSHY Max	W1790H2	-287,156	287,1555	0,000051	1,9	2,68421E-05	0,0009	0,000927	İçinde	İçinde	İçinde	MH
2.KAT	W1790	PUSHY Min	W1790H2	-521,779	521,7739	-3E-06	1,9	1,57895E-06	0,0009	0,000902	İçinde	İçinde	İçinde	MH
1.KAT	W1781	PUSHY Max	W1781H3	-296,275	296,275	0,000129	1,9	6,78947E-05	0,0009	0,000968	İçinde	İçinde	İçinde	MH
1.KAT	W1781	PUSHY Min	W1781H3	-493,199	493,1991	-4E-06	1,9	2,10526E-06	0,0009	0,000902	İçinde	İçinde	İçinde	MH
1.KAT	W1782	PUSHY Max	W1782H3	-505,061	505,0611	0,000141	1,9	7,42105E-05	0,0009	0,000974	İçinde	İçinde	İçinde	MH
1.KAT	W1782	PUSHY Min	W1782H3	-2601,7	2601,7006	1,91E-07	1,9	1,00526E-07	0,0009	0,0009	İçinde	İçinde	İçinde	MH
1.KAT	W1787	PUSHY Max	W1787H3	-601,671	601,6705	0,000149	1,9	7,84211E-05	0,0009	0,000978	İçinde	İçinde	İçinde	MH
1.KAT	W1787	PUSHY Min	W1787H3	-511,785	511,7063	-6E-06	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
1.KAT	W1788	PUSHY Max	W1788H3	-578,413	578,4132	0,000149	1,9	7,84211E-05	0,0009	0,000978	İçinde	İçinde	İçinde	MH
1.KAT	W1788	PUSHY Min	W1788H3	-877,289	877,2886	-6E-06	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
1.KAT	W1789	PUSHY Max	W1789H3	-269,96	269,9603	0,000135	1,9	7,10526E-05	0,0009	0,000971	İçinde	İçinde	İçinde	MH
1.KAT	W1789	PUSHY Min	W1789H3	-307,793	307,7932	-5E-06	1,9	2,63158E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
1.KAT	W1790	PUSHY Max	W1790H3	-512,656	512,6561	0,000145	1,9	7,63158E-05	0,0009	0,000976	İçinde	İçinde	İçinde	MH
1.KAT	W1790	PUSHY Min	W1790H3	-2504,72	2504,716	-1E-06	1,9	5,26316E-07	0,0009	0,000901	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1781	PUSHY Max	W1781H4	-660,795	660,7947	0,004	1,9	0,002105263	0,0009	0,003005	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1781	PUSHY Min	W1781H4	-880,063	880,0633	0,000001	1,9	5,26316E-07	0,0009	0,000901	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1782	PUSHY Max	W1782H4	-778,839	778,839	0,004485	1,9	0,002360526	0,0009	0,003261	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1782	PUSHY Min	W1782H4	-2616,9	2616,902	-6E-06	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1787	PUSHY Max	W1787H4	-3061,82	3061,819	0,004475	1,9	0,002355263	0,0009	0,003255	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1787	PUSHY Min	W1787H4	-1385,08	1385,076	4,77E-08	1,9	2,50895E-08	0,0009	0,0009	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1788	PUSHY Max	W1788H4	-3021,85	3021,454	0,004438	1,9	0,002354737	0,0009	0,003255	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1788	PUSHY Min	W1788H4	-1306,88	1326,882	-1E-06	1,9	5,26316E-07	0,0009	0,000901	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1789	PUSHY Max	W1789H4	-656,611	656,6114	0,004489	1,9	0,002362632	0,0009	0,003263	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1789	PUSHY Min	W1789H4	-903,887	903,8869	0,000002	1,9	1,05263E-06	0,0009	0,000901	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1790	PUSHY Max	W1790H4	-788,625	788,6254	0,004477	1,9	0,002356316	0,0009	0,003256	İçinde	İçinde	İçinde	MH
ZEMİN KAT	W1790	PUSHY Min	W1790H4	-2712,96	2712,964	-6E-06	1,9	3,15789E-06	0,0009	0,000903	İçinde	İçinde	İçinde	MH

- Existing Shear Walls Damage levels X dir. / *Mevcut Perde Hasar Durumu Y yönü*

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

- Summary table X direction retrofitted building satisfied TEC 2007 / *Mevcut durum analizinde kullanılan aynı yöntemler ile hesaplanan hedef deplasmana kadar itilen itme analizi neticesinde yapılan performans analizinde yapı DBYBHY 2007 kriterlerini sağlar hale*

MASTERFRAMESİZ MODEL / PUSH X	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	32\36	4\36		36\44	6\44	2/44	4\4		
2.KAT	33\36	3\36		36\44	6\44	2/44	4\4		
1.KAT	34\36	2\36		36\44	6\44	2/44	4\4		
ZEMİN KAT	34\36	2\36		36\44	6\44	2/44		4\4	

MASTERFRAMELİ MODEL / PUSH X	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36\36			34\44	4\44		4\4	-	
2.KAT	36\36			34\44	4\44		4\4	-	
1.KAT	36\36			34\44	4\44		4\4	-	
ZEMİN KAT	36\36			34\44	4\44		4\4	-	

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDELİ 4 KATLI*

- Summary table Y direction retrofitted building satisfied TEC 2007 Mevcut durum analizinde kullanılan aynı yöntemler ile hesaplanan hedef deplasmana kadar itilen itme analizi neticesinde yapılan performans analizinde yapı DBYBHY 2007 kriterlerini sağlar hale gelmiştir.

MASTERFRAMESİZ MODEL / PUSH Y

	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36\36			32/38	6/38		6\6		
2.KAT	36\36			29/38	8/38		6\6		
1.KAT	36\36			30/38	8/38		6\6		
ZEMİN KAT	36\36			32/38	6/38			6\6	

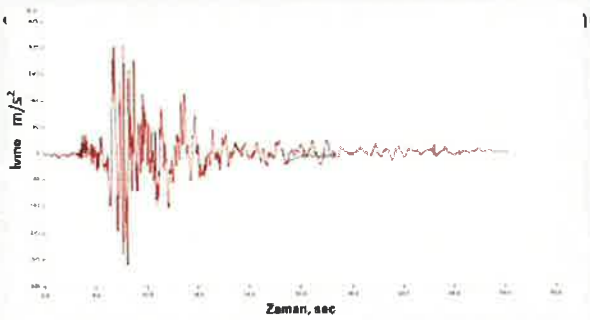
MASTERFRAMELİ MODEL / PUSH Y

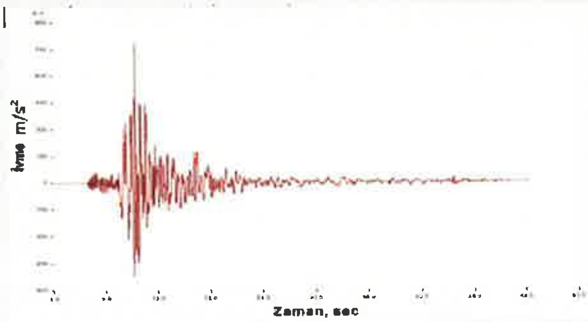
	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36\36			36\38	2\38		6\6		
2.KAT	36\36			34\38	4\38		6\6		
1.KAT	36\36			34\38	4\38		6\6		
ZEMİN KAT	36\36			34\38	4\38		6\6		

RETROFITTED BUILDING USING MaSTER FRAME © – 4 STOREY WITH SHEAR WALLS- TIME HISTORY / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI – PERDELİ 4 KATLI – ZAMAN TANIM ALANINDA ANALİZ*

- Non-linear time history analysis were performed in second stage for confirmation purpose using scaled convinient earthquake datas / *İkinci aşamada daha doğru sonuçlar alınabilen Zaman Tanım Alanında uygun deprem dataları ölçeklenerek doğrusal olmayan analizler yapılmıştır.*
- Bolu, Düzce, Ercincan, hector, Kobe, Kocaeli, Lander acc. Records were used for THA / *Zaman tanım alanında analiz için BOLU, DÜZCE, ERZİNCAN, HECTOR, KOBE, KOCAELİ, LANDER ivme kayıtları ölçeklendirilerek kullanılmıştır.*

ıdiril

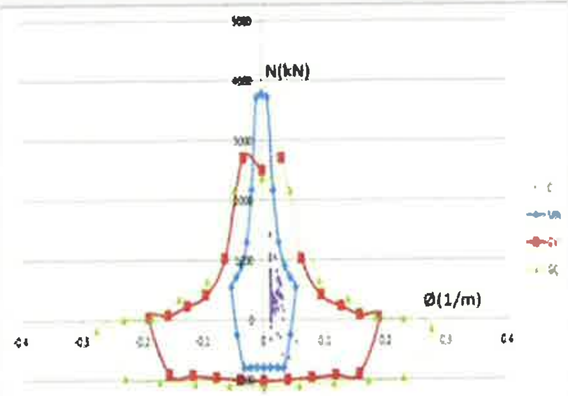




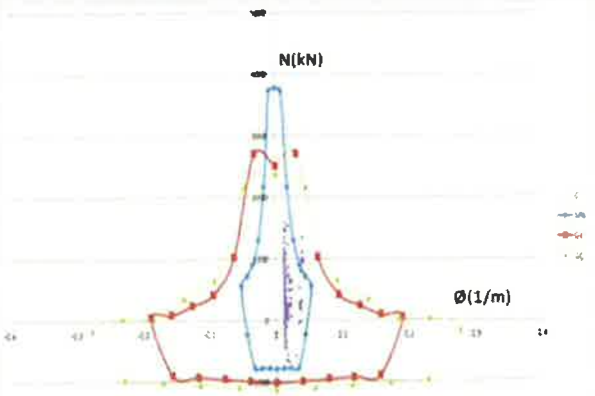
- Bolu FN scaled record / *Bolu Depremi FN Ölçeklendirilmiş Kaydı*
- Bolu FP scaled record / *Bolu Depremi FP Ölçeklendirilmiş Kaydı*
- Değerlendirme için kullanılan 7 depremin binaya geliş yönleri değiştirilerek 14 ayrı analiz yapılmıştır. Sonuçların ortalaması alınarak bina değerlendirmeye tabi tutulmuştur.

MaSTERFRAME© KULLANILARAK GÜÇLENDİRME ÇALIŞMASI- PERDELİ YAPI 4 KATLI ZAMAN TANIM ALANINDA ANALİZ

- Mean values of 7 THA results were used for assessment as per TEC 2007 / *Zaman Tanım Alanında 7 deprem için yapılan analizlerin etkilerinin DBYBHY 2007'ye göre ortalamaları alınarak değerlendirme yapılmıştır.*
- Determined results were compared with Static pushover results and rather close results were obtained / *Elde edilen veriler Statik itme analizleri ile karşılaştırmalı olarak verilmiştir. Sabit Modlu itme analizi ile 7 depremli zaman tanım alanında yapılan analiz sonuçları birbirine oldukça yakın bulunmuştur.*



- X-dir Columns Static Pushover / *Kolonlar X yönü Statik İtme*



- X-dir Columns THA / *Kolonlar X yönü Zaman Tanım Alanında*

EXISTING BUILDING INFORMATION – 3 STOREY WITHOUT SHEAR WALL / *MEVCUT YAPI BİLGİLERİ –PERDESİZ 3 KATLI*

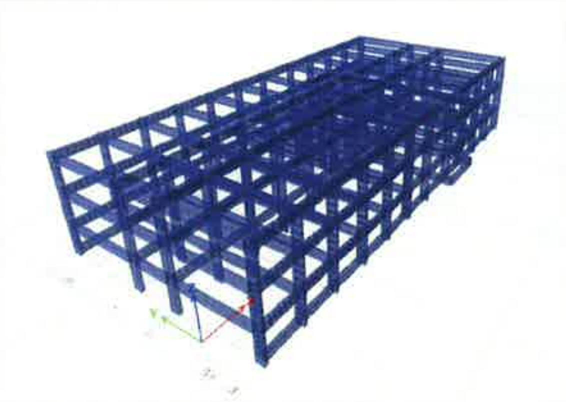
- Typical School Building / *Tipik Okul Binası*
- C15.0 Mpa, STIII, Constraction date /*Yapım Yılı*: 2000 before /*öncesi*, Soil/*Zemin* Z3 C
- Earthquake zone / *Deprem Bölgesi* : I.
- Live Load Participation Factor / *Hareketli Yük Katılım Katsayısı*: 0.60
- Floor loads / *Döşeme Yükleri*: G=0.212 t/m2, Q=0.350 t/m2
- Roof Level Loads / *Çatı katı Yükleri*: G=0.149 t/m2, Q=0.225 t/m2
- Partition Wall weight / *Duvar Ağırlığı* 0.39 t/m2
- Structure Type / *Yapı Tipi*: Reinforced concrete frame / *Betonarme Çerçeve*
- Foundation type / *Temel Tipi:* Continuous footing / *Sürekli Temel*
- Proposed performance / *Öngörülen Performans*: Immediate Occupancy in earthquka with 10 % exceedence probability in 50 years / *50 yılda aşılma olasılığı % 10 olan depremde Hemen Kullanım*

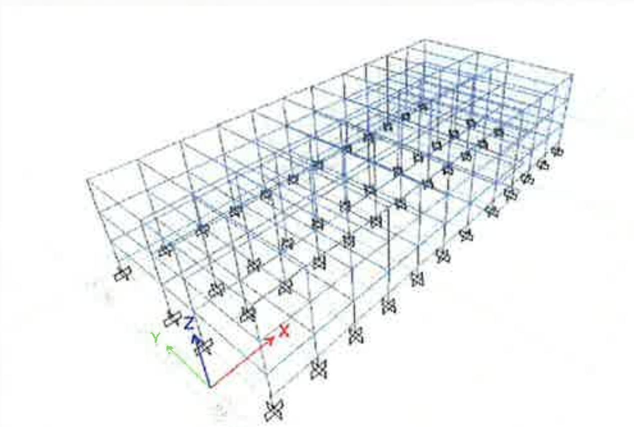
Kat Bilgileri:

İsim	No	Yükseklik (m)	Alan (m2)
Zemin Kat	1	2,9	760
1. Kat	2	2,9	760
2. Kat	3	2,9	760

EXISTING BUILDING INFORMATION – 3 STOREY WITHOUT SHEAR WALL / *MEVCUT YAPI BİLGİLERİ –PERDESİZ 3 KATLI*

- Structure is modelled in ETAPS ver 16 using frame members with plastic joint and shear walls with fiber modeling / *Kolon ve Kirişler yığılı plastik mafsallı çubuk eleman olarak modellenmiştir.*
- Plastic joint properties are the same with 4 storey building model / *Yığılı plastik mafsal özellikleri ve modelleme teknikleri perdeli model ile aynıdır.*





- ETABS Modeli

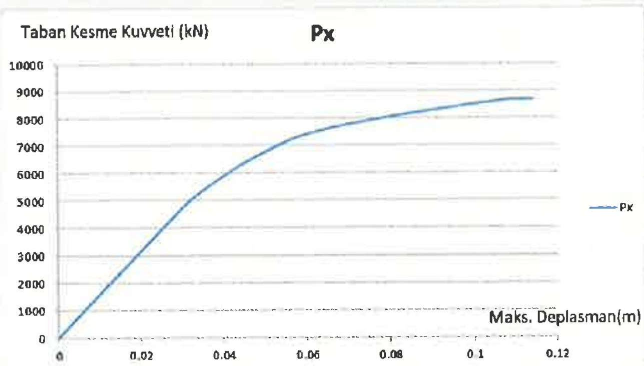
EXISTING 3 STOREY BUILDING INFORMATION WITHOUT SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDESİZ 3 KATLI*

- Target displacement is determined for assessment purpose as per TEC 2007 / *Performans analizi amaçlı yığılı mafsal modellenmiş yapı için DBYBHY 2007'ye göre hedef deplasman hesabı yapılmıştır*

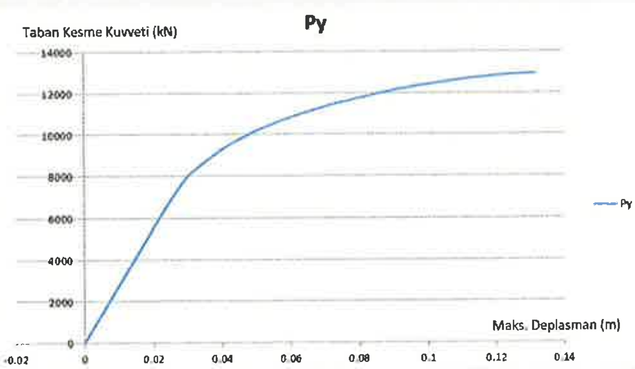
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	hedef deplasman (m) uxN1
0.62	2.435273	9.556011	0.974109	0.093047					0.113872484

Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.52	2.5	9.81	1	0.067192	4.021894	2.439145	1.090772	0.073291	0.094607095

- Target Displacement of 3 Storey school building / *Perdesiz 3 Katlı Tipik Okul Binası Hedef Deplasman*



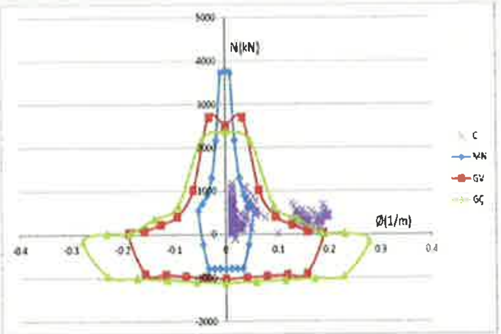
- X dir Capacity curve / X yönü Kapasite Eğrisi



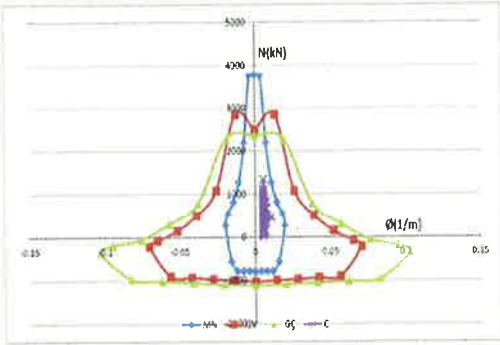
- Y dir Capacity Curve / Y yönü Kapasite Eğrisi

EXISTING 3 STOREY BUILDING INFORMATION WITHOUT SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDESİZ 3 KATLI*

- Existing building is performed pushover analysis up to target displacement for assessment purpose and and determined as satisfying TEC 2007 for X and Y direction respectively / *Perdeli yapı ile aynı şartlarda yapılan sabit modlu artımsal itme analizi yapının X ve Y yönleri için hesaplanmış hedef deplasman miktarı kadar artımsal itilmiştir.*
- Axial load-curvature values calculated from pushover –target displacement analysis were placed in the graphs to see damage levels / *Hedef deplasmana ulaşan yapıda mevcut elemanlar için elde edilen sonuçlar kullanılarak P-Ø verileri elde edilmiş ve sınır eğrileri ile kontrol edilmiştir.*
- Existing colums were determined as satisfying the code for Y direction, There are columns in collapse prevention damage level in X direction. Building needs retrofitting. / *Mevcut yapı kolonları Y yönünde yeterli olmasına karşın X yönünde göçme sınırı üzerinde yapının güçlendirmeye ihtiyacı vardır.*



- Push X Kolon Performans



- Push Y Kolon Performans

EXISTING 3 STOREY BUILDING INFORMATION WITHOUT SHEAR WALLS / *MEVCUT YAPI BİLGİLERİ –PERDESİZ 3 KATLI*

- Assesment Summary Table for 3 storey building / *3 Katlı perdesiz yapı için yapılan hedef deplasman miktarına kadar sabit modlu itme analizinde elde edilen sonuçlar tablolandığında X yönünde mevcut bina için özellikle kolonların ileri hasar ve göçme bölgesinde olduğu görülmektedir. Y yönü yeterli görünmektedir.*

MASTERFRAMESİZ MODEL / PUSH X

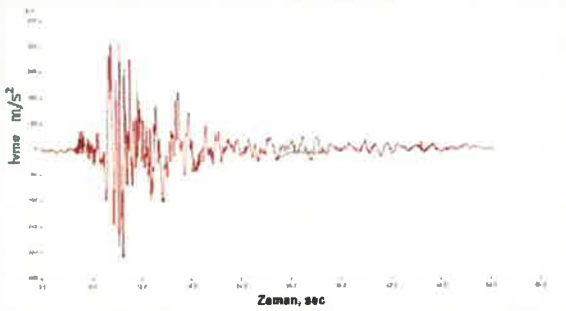
	KOLON				KİRİŞ		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	Göçme	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
2.KAT	48\48	0\48	0\48	0\48	44\44	0\44	0/44
1.KAT	25\48	2\48	6\48	15\48	35\44	9\44	0/44
ZEMİN KAT	33\48	15\48	0\48	0\48	36\66	7\66	1/66

MASTERFRAMESİZ MODEL / PUSH Y

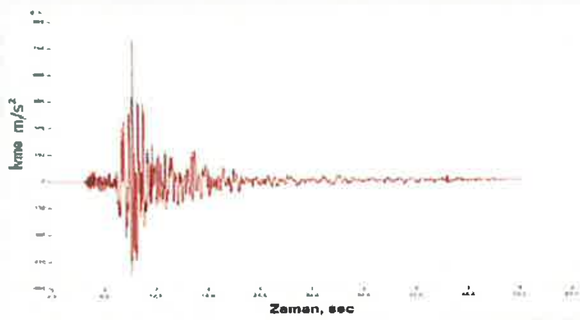
	KOLON				KİRİŞ		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	Göçme	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
2.KAT	48\48	0\48	0\48	\48	44\44	0\44	0/44
1.KAT	48\48	0\48	0\48	\48	32\44	12\44	0/44
ZEMİN KAT	48\48	0\48	0\48	\48	49\66	10\66	7/66

RETROFITTED BUILDING USING MaSTER FRAME © – 3 STOREY WITHOUT SHEAR WALLS - TIME HISTORY / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDESİZ 3 KATLI – ZAMAN TANIM ALANINDA ANALİZ*

- Non-linear time history analysis were performed in second stage for confirmation purpose using scaled convinient earthquake datas / *Bir önceki aşamada yaklaşık bir yöntem olan sabit modlu itme analizi kullanılmıştır.*
- Bolu, Düzce, Ercincan, hector, Kobe, Kocaeli, Lander acc. Records were used for THA / *Zaman tanım alanında analiz için BOLU, DÜZCE, ERZİNCAN, HECTOR, KOBE, KOCAELİ, LANDER ivme kayıtları ölçeklendirilerek kullanılmıştır.*



- Bolu Depremi FN Ölçeklendirilmiş Kaydı

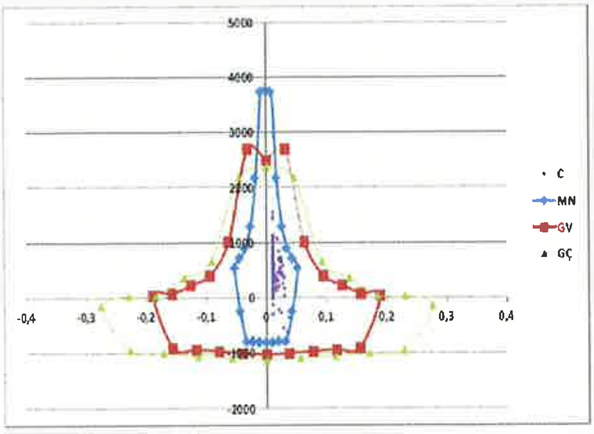


- Bolu Depremi FP Ölçeklendirilmiş Kaydı

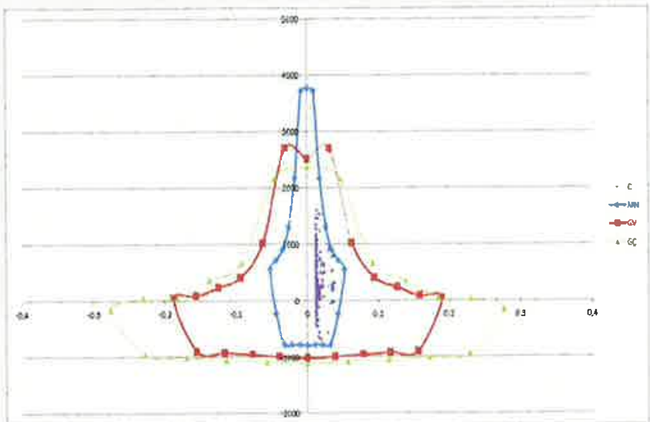
- Değerlendirme için kullanılan 7 depremin binaya geliş yönleri değiştirilerek 14 ayrı analiz yapılmıştır. Sonuçların ortalaması alınarak bina değerlendirmeye tabi tutulmuştur.

RETROFITTED BUILDING USING MaSTER FRAME © – 3 STOREY WITHOUT SHEAR WALLS - TIME HISTORY / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDESİZ 3 KATLI – ZAMAN TANIM ALANINDA ANALİZ*

- Mean values of 7 THA results were used for assessment as per TEC 2007. Results were assessed and compared with Pushover analysis / *Son aşamada MF ile güçlendirilmiş yapı sabit modlu itme analizi ve 7 deprem kullanılarak yapılan zaman tanım alanında analiz sonuçları karşılaştırılarak değerlendirilmiştir. Y yönü mevcut durumda yeterli göründüğü için değerlendirme X yönü için yapılmıştır.*



- Sabit Modlu İtme Analizi Kolonlar X yönü Performans Değerlendirmesi

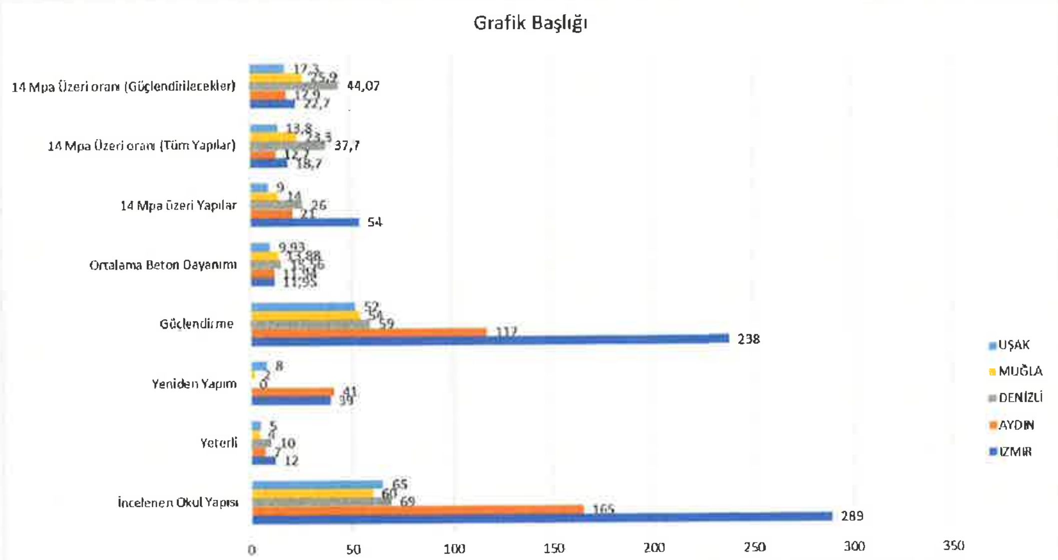


- Zaman Tanım Alanında 7 Depremli Analizler Ortalaması Kolonlar X yönü Performans Değerlendirmesi

RETROFITTED BUILDING USING MaSTER FRAME © – 3 STOREY WITHOUT SHEAR WALLS - TIME HISTORY / *MaSTER FRAME © İLE GÜÇLENDİRİLMİŞ YAPI –PERDESİZ 3 KATLI – ZAMAN TANIM ALANINDA ANALİZ*

- Typical school building were retrofitted so as to meet TEC 2007 using MaSTERFRAME© members in front and back faces / Tipik Okul binası MaSTERFRAME© yöntemi ile yapı dışından ve sadece ön ve arka cephelere yerleştirilen MF elemanları ile DBYBHY 2007 kriterlerini sağlayacak şekilde güçlendirilmiştir.
- There were no need to enter the building due to MF technology and used disc anchorages / *Yapı içine girilmemiş, Disk Ankrajlar ile yapılan bağlantılar ile yapı kullanımına engel olunmamıştır.*
- No Windows or doors were closed leading no decrease getting sun inside / *Cephe pencere, kapı vs. kapatılmamış güneşlenme etkilenmemiştir.*
- MF retrofitting constraction may be completed in 3-3.5 months such as a summer time period / *3-3.5 ay gibi inşaat süresi ile yaz sezonunda yapılabilecek bir uygulamadır.*

STATISTICS SCHOOL BUILDINGS POSSIBLY MF CAN BE APPLIED / MF UYGULANABİLECEK OKUL YAPISI İSTATİSTİKLERİ



	İncelenen Okul Yapısı	Yeterli	Yeniden Yapım	Güçlendirme	Ortalama Beton Dayanımı	14 Mpa üzeri Yapılar	14 Mpa Üzeri oranı (Tüm Yapılar)	14 Mpa Üzeri oranı (Güçlendirilecekler)
UŞAK	65	5	8	52	9,93	9	13,8	17,3
MUĞLA	60	4	2	54	13,88	14	23,3	25,9
DENİZLİ	69	10	0	59	15,56	26	37,7	44,07
AYDIN	165	7	41	117	11,94	21	12,7	17,9
İZMİR	289	12	39	238	11,95	54	18,7	22,7

Garanti Koza | Maeda Corporation

GKMC İnşaat ve Danışmanlık A.Ş.

MaSTER FRAME® TEKNOLOJİSİ İLE İLGİLİ TÜRKİYE'DE YAPILAN ÇALIŞMALAR ve İŞ MODELİ HAKKINDA

INTRODUCTION OF MaSTER FRAME® TECHNOLOGY ACTIVITIES AND BUSINESS MODEL IN TURKEY

GKMC İnşaat ve Danışmanlık A.Ş.
November 4th 2018

Outline Chronology of Business Activities in Turkey Regarding MaSTER FRAME (MF) Method.

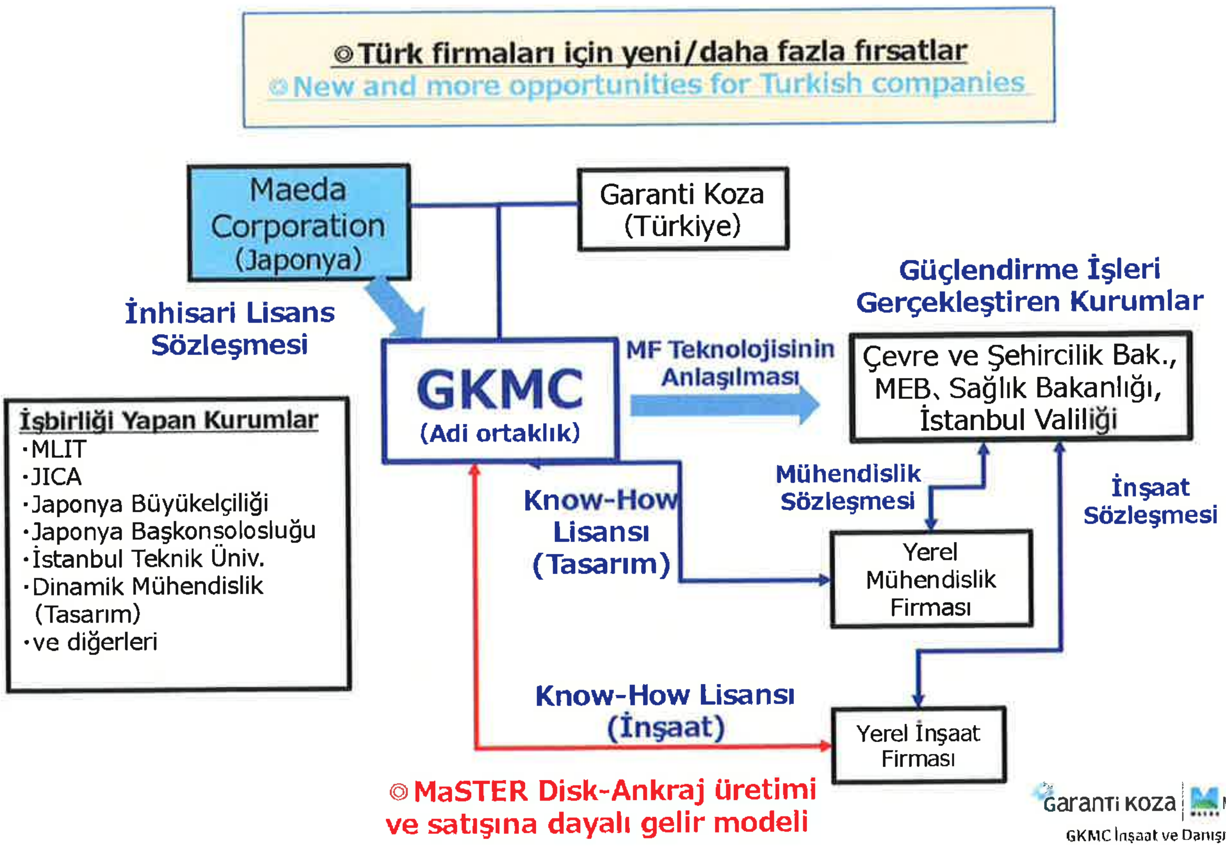
- **Jan-Oct 2016** : Initial approach to local engineering firms and local key players and potential stakeholders.
- **Nov. 2016** : First contact with public institutions. Visit MoNE to introduce MF method (total 3 times)
- **Mar. 2017** : Start legal activities. **Application for Intellectual Property Rights** (Patent, Trademark and Industrial Design) to Trademark and Patent Office of Turkey.
- **Oct. 2017** : Visit MoEU, Construction Works Directorate to introduce MF method for anti-seismic construction works and propose **Pilot Project**. The academic study of MF method was requested.
- **Dec 2017** : Visit Istanbul Governorship to introduce MF method
- **Feb. 2018** : Submit **Provisional Design Report** of MF method to MoEU and Istanbul Governorship Office, IPKB
- **Mar. 2018** : **Establish Task Force at Istanbul Technical University** (İTÜ-EEDMI) for technical and academic evaluation of MF method as per the request from MoEU. Preliminary study commenced.
- **Apr. 2018** : Detailed presentation of MF Provisional Design Report to IPKB and propose **Pilot Project.**
- **May 2018** : Start MaSTER Disk-Ankraj shear tests on low-strength concrete at ITU Laboratuary.
- **May. 2018** : IPKB and ULKER consented to design one building in the package by MF method as **Pilot Project** subject to cost comparison (from ISMEP tender package)
- **July 2018** : Commence an Agreement with JICA: "Disseminating Japanese Technology for Retrofitting Engineering Services"
- **July 2018** : Officially start Task-Force and academic studies for MaSTER FRAME Method.
- **Aug. 2018** : Initiate technical/industrial certification process for MaSTER Disk-Ankraj; **UTO**
- **Oct 2018** : Initial NDA Agreement is commenced with a local Turkish manufacturer to product DA in Turkey.
- **Oct 2018** : Conduct Task-Force meeting at MoEU in Ankara to share **provisional results of TF studies**

OYUNCULAR VE TEKNOLOJİ / KEY PLAYERS AND TECHNOLOGY

Anahtar Kelimeler / Key Words

1. Maeda Corporation	: Maeda firması, bu teknolojinin ve teknik bilginin asıl sahibidir. Maeda Corporation is the original owner of the Technology and Know-How
2. Teknoloji Transferi Technology Transfer	: Maeda firması, Lisans Sözleşmeleri vasıtası ile bu teknik bilgiyi (Know-How) Türk firmalarına verecektir. Maeda is intended to provide Turkish companies with the Technology and relating Know-How via License Agreements.
3. Teknik Bilgi Know-How	: Mühendislik, uygulama ve teknik deney verilerini içeren, **Kılavuz** kapsamındaki bilgi bütünüdür (üniversite ve ilgili kuruluş onaylı) Means engineering, construction execution, experimental technical data (Booklet) completed in Japan (authorized/verified by universities and independent 3rd party institution)
4. MaSTER Disk-Ankraj	: MaSTER FRAME Metodu için imal edilmiş kilit bir malzeme/ankraj. A key material specially developed for MaSTER FRAME.
5. GKMC	: Türkiye'nin ilk Türk-Japon eşit ortaklıklı inşaat firması. Maeda, MF ile ilgili Fikri ve Sınai Hakları ve Know-How'ı kapsayan İnhisari Lisans haklarını GKMC'ye vermiştir. **Türkiyede tek yetkili lisans sahibi GKMC'dir.** Turkey's first Turkish-Japanese equal-joint stock construction company. GKMC has been awarded Exclusive License by Maeda for MF, including relating Intellectual Rights and Know-How. **GKMC is the sole Exclusive Licensee in Turkey.**

Teknoloji Transferi İş Modeli Şeması
Business Model for MF Technology Transfer



İş Modeli ile İlgili Önemli Hususlar
Key Points of Business Model

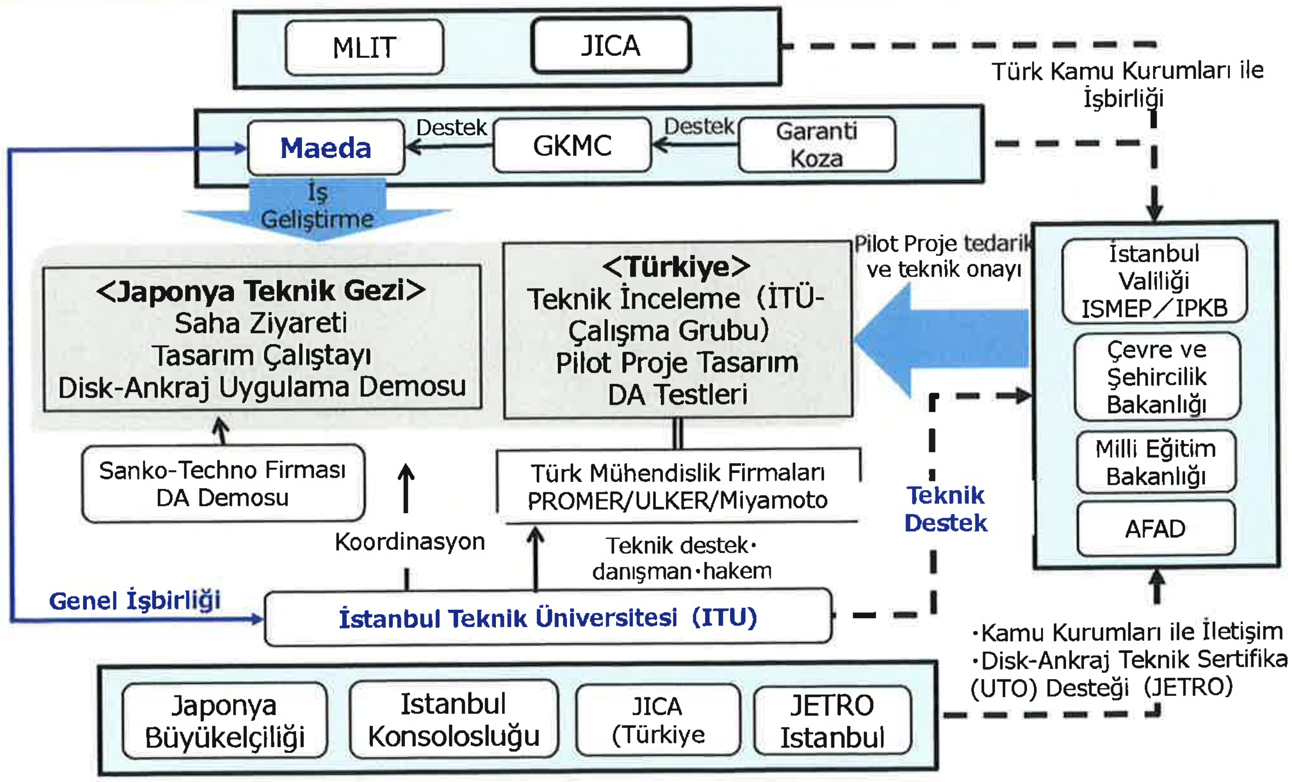
- ❑ Maeda/GKMC'nin ana motivasyonu: Türk toplumunun sosyal bir sorununa, deprem tecrübesi olan Japonya'dan alternatif bir çözüm.
  Motivation of Maeda/GKMC : To provide an alternative solution to Turkish society from Japan experienced in antiseismic solutions.
- ❑ Maeda/GK/GKMC mühendislik ve uygulama (imalat) işleri ile **ilgilenmemektedir.**
  Maeda/GK/GKMC does not intend to involve in enginnering and construction works
- ❑ MF metodunu; Türk mühendislik firmaları tasarlayacak, Türk firmaları uygulayacaktır.
  MF Method will be designed and executed by local Turkish companies.
- ❑ Yerli üretim. Disk-Ankraj'ı Türkiye'de yerli üreticiler üretecektir.
  Domestic Production : DA will be manufactured by local (Turkish) manufacturers
- ❑ Bu iş modelinde asli unsurlar yerli firmalar olacaktır. Ne Maeda ne GKMC yerel firmalara rakiptir.
  Turkish companies will benefit most with current Business Model. Neither Maeda nor GKMC is competitor to local companies.
- ❑ GKMC sadece Disk-Ankraj'ları tedarik edecek ve mütevazi bir gelir elde edecektir.
  GKMC will solely provide Disk-Ankraj and will possess humble revenue

❑Ortak Değer Yaratma : **Türk firmaları için daha fazla iş imkanı**
CSV : **More business opportunities for Turkish companies**

Garanti Koza | Maeda Corporation
GKMC İnşaat ve Danışmanlık A.Ş.

JICA Programı Özet Şeması
Summary of JICA Program

◎ JICA Programının Paydaşları → Çevre ve Şehircilik Bakanlığı ve İstanbul Valiliği



Thank you very much for listening.

Teşekkür ederim.

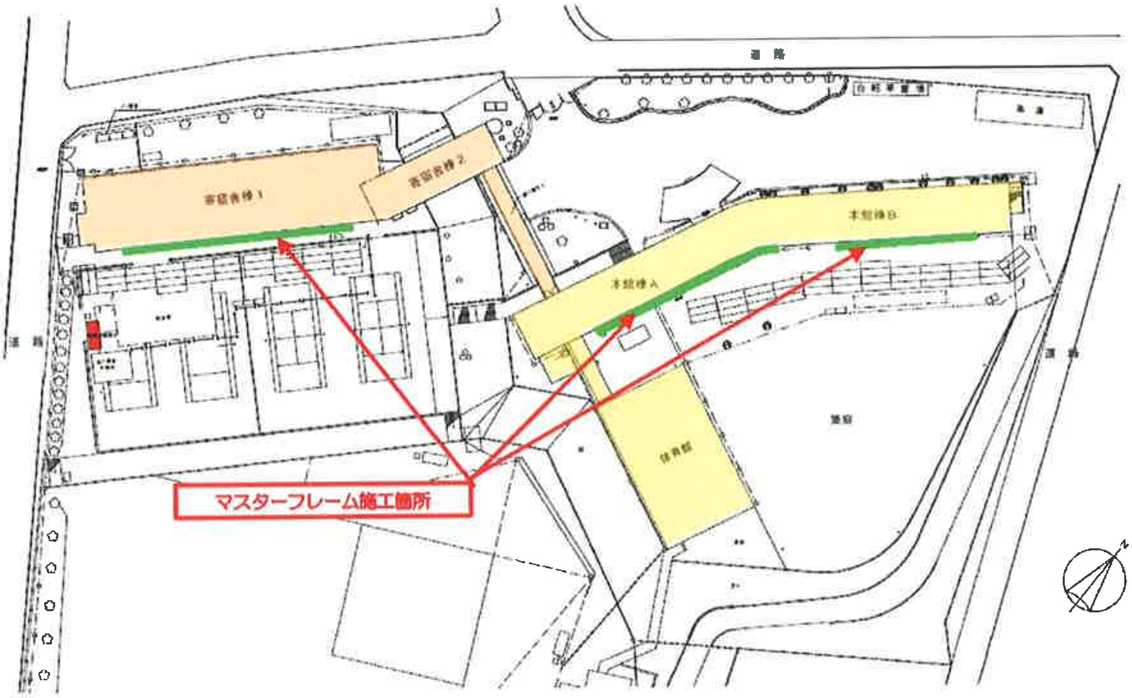
ご清聴ありがとうございます。

東北郵政研修センター
耐震改修模様替その他工事

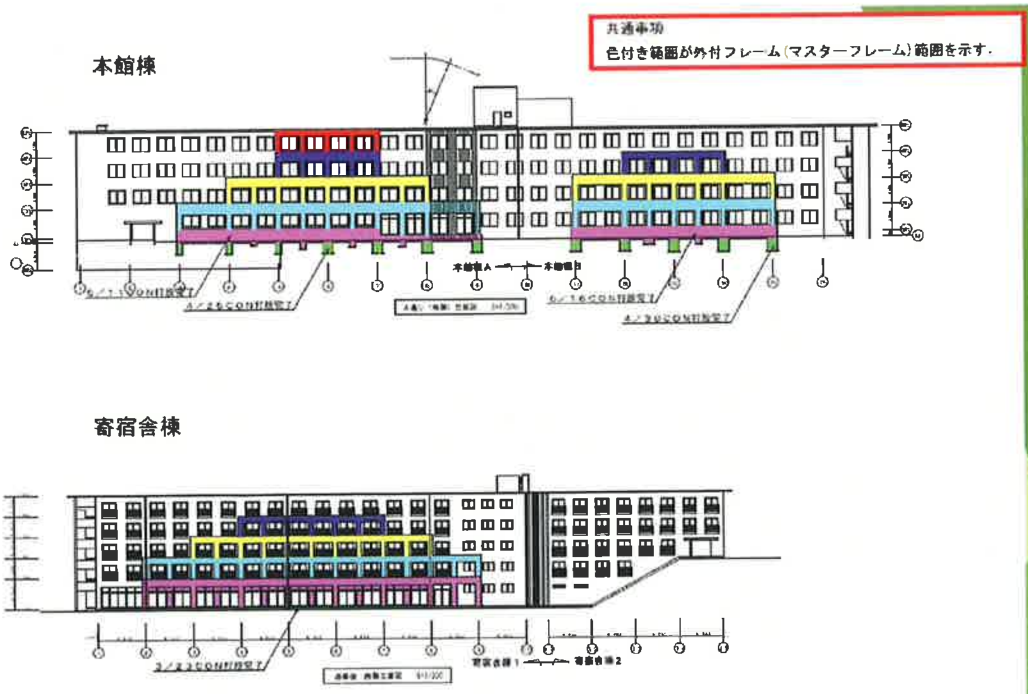
東北郵政研修センター耐震改修模様替その他工事

工事概要

1　工事名称　　東北郵政研修センター耐震改修模様替その他工事
2　工事場所　　宮城県仙台市太白区八木山本町2-11-1
3　工事建物名称　　東北郵政研修センター
4　建物概要
　本館棟A　　鉄筋コンクリート造　地下1階地上4階　延床面積　2,748㎡
　本館棟B　　鉄筋コンクリート造　地上4階　延床面積　1,831㎡
　寄宿舎棟1　　鉄筋コンクリート造　地上5階　延床面積　3,325㎡
　寄宿舎棟2　　鉄筋コンクリート造　地上4階　延床面積　643㎡
5　工期　　自：平成25年1月9日
　　　　　至：平成25年9月15日
6　発注者　　日本郵便株式会社
7　設計監理者　　日本郵政株式会社　東北施設センター
8　請負者　　前田建設工業株式会社東北支店
　　宮城県仙台市青葉区二日町4番11号
　　TEL 022－225－8336
　　常務執行役員支店長　青木　敏久
9　施工管理　　前田建設工業株式会社東北支店
　　宮城県仙台市青葉区二日町4番11号
　　TEL:022－225－8336
　　監理技術者：後藤　謙
　　現場代理人：後藤　謙
　　建築職員：嵩井　英伸
　　建築職員：佐々木　敏治
10　工事概要
　本館棟　　耐震補強外付けフレーム工事
　　内部耐震補強構造躯体工事
　　内部耐震補強鉄骨フレーム取付工事
　　内外部災害被害調査及び修理復旧工事
　　建築工事に関係する設備施設　撤去復旧工事
　寄宿舎棟　　耐震補強外付けフレーム工事
　　内部耐震補強構造躯体工事
　　建築工事に関係する設備施設　撤去復旧工事
　両棟　　工事使用影響部の外構復旧・更新工事



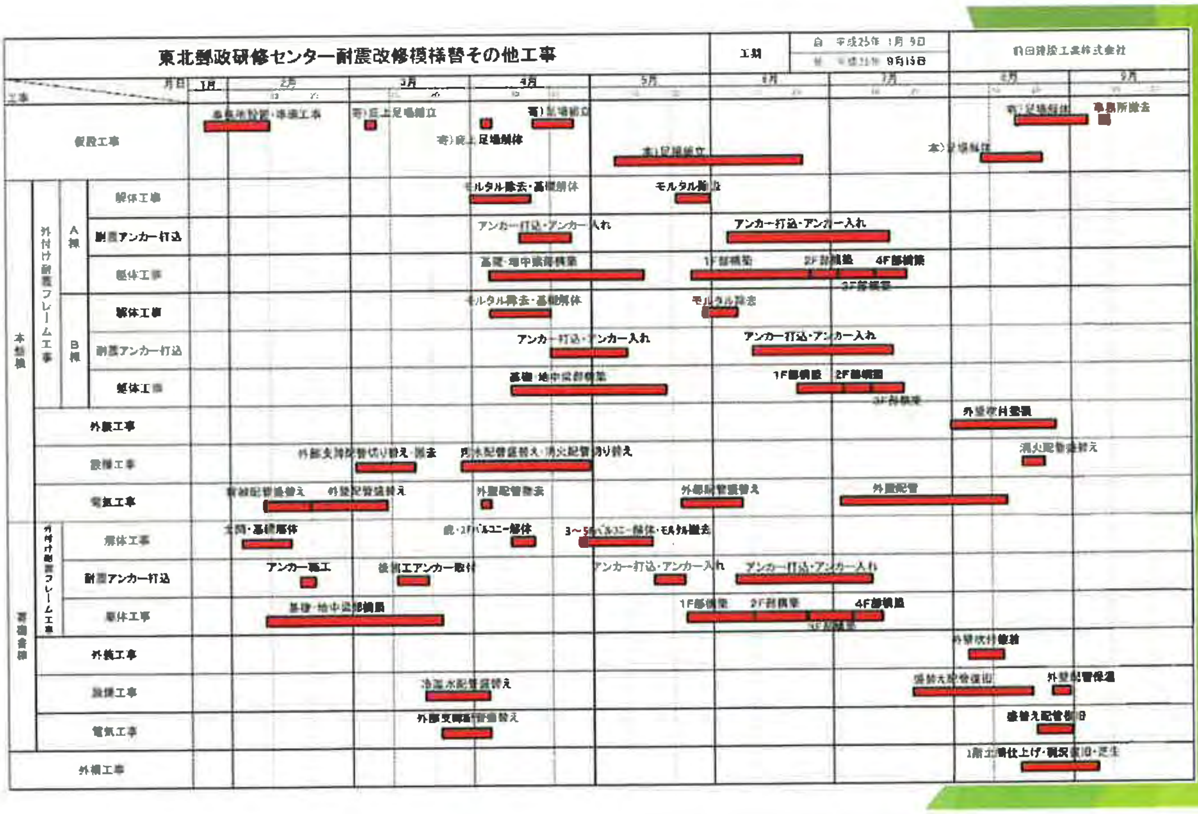
全体配置図



本館棟・寄宿舎棟 マスターフレーム範囲図

フローチャート

外部足場組立
↓
鉄筋位置探査
↓
アンカー位置墨出し
↓
ディスクアンカー削孔・固定
↓
鉄筋組立
↓
アンカーボルト挿入
↓
型枠組立
↓
コンクリート打設
↓
型枠解体
↓
左官補修
↓
目地コーキング
↓
外壁仕上げ塗装
↓
外部足場解体



工事状況画像－１

外部足場組立(寄宿舎棟)

外部足場組立(本館棟)

既存躯体鉄筋探査

アンカー位置墨出し

ディスクアンカー削孔

ディスクアンカー定着

工事状況画像－２

ディスクアンカー定着完了

柱筋地組

柱筋吊込み

型枠建込(梁底)

梁筋組立

梁筋組立完了

工事状況画像－３


アンカー筋挿入


型枠組立完了


コンクリート打設


型枠解体


左官補修完了


外部仕上げ塗装

本館棟


着工前


竣工後

寄宿舎棟

着工前

竣工後

MaSTER FRAME構法の利点

◎環境面

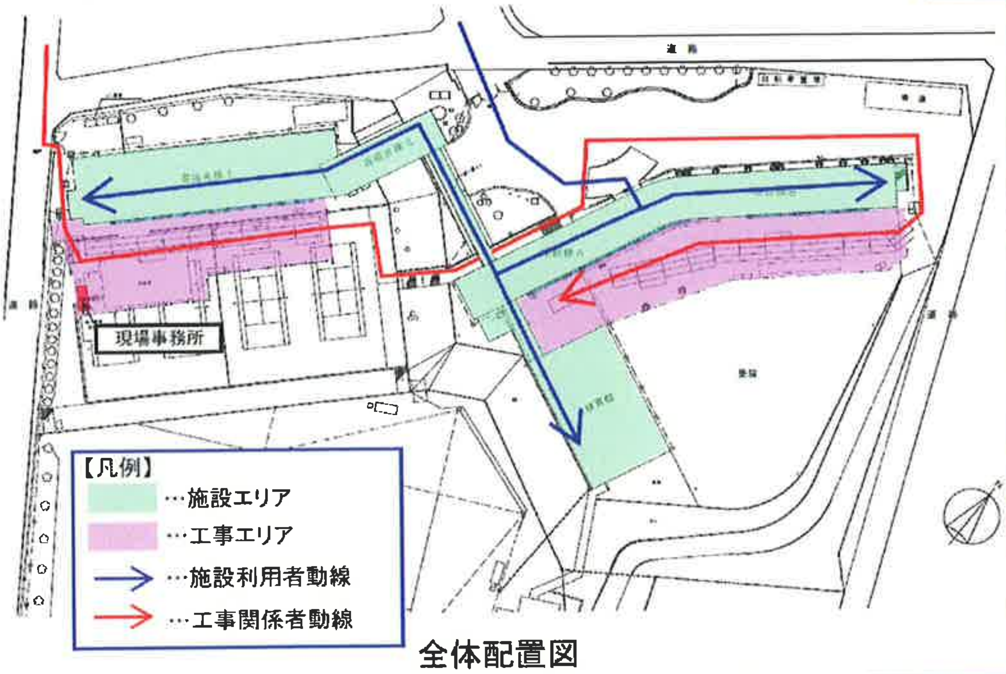
・全て外部からの施工であり、室内の利用に影響を与えない。

・工事中の室内環境が維持できる。

本館棟　教室

寄宿舎棟　居室

・室内施設利用者と作業員の動線を確実に分離できる。



全体配置図

・アンカー作業(サイレント工法による削孔・アンカー挿入等)、鉄筋組立作業においては、騒音は内部においてもほとんど感じない為、工事期間中の教室の利用制限等といった調整は行っていない。

No.	測定部位	棟	作業内容							
			モルタル撤去				アンカー打ち込み			
			カッター入れ		モルタルはつり		ハンマードリル		サイレント工法	
			騒音測定レベル（平均）db	感覚判定 ○ × △	騒音測定レベル（平均）db	感覚判定 ○ × △	騒音測定レベル（平均）db	感覚判定 ○ × △	騒音測定レベル（平均）db	感覚判定 ○ × △
1	1F総務部	B	64	○	54	○	61	○	※	○
2	1F会議室	A	43	○	52	○	54	○	40	○
3	2F郵便端末機械室	A	56	△	60	△	63	△	—	—
4	2F貯金端末教室	A	50	○	57	△	48	△	—	—
5	3F302教室	A	56	△	59	△	62	○	—	—
6	3F情報系共用端末教室	A	48	○	55	○	44	○	38	○
7	3F合同教室	B	47	○	55	○	47	○	—	—
8	4F401教室	A	58	×	58	×	54	△	—	—
9	4F402教室	A	58	△	51	○	49	○	—	—
10	4F403教室	A	51	△	48	○	47	○	—	—
11	4F404教室	A	45	○	46	○	40	○	—	—
12	4Fさわやか郵便局	B	56	△	53	○	54	○	—	—
13	4F講堂	B	44	○	48	○	44	○	—	—
14	3F301教室	A	—	—	—	—	62	△	—	—
15	1F男子便所	B	78	×	91	×	87	×	63	△

◎ 測定は、1箇所10秒程度で行い、その間の平均db記入

◎ 感覚は、実習や業務に対しての影響度合いを記入

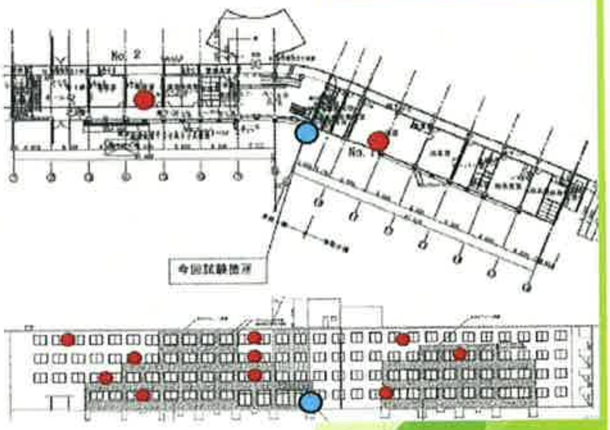
※ …該当騒音以外の暗騒音(話し声、物音)の方が騒音レベルが高い為、測定不能

○（青） …特に影響なし

△（黄） …短時間、マイク使用なら支障なし

×（赤） …研修や業務が出来ない

○（緑） …業務は可能



・施工中足場はグリーンネット程度であり、ガラス面から十分採光を取ることが出来た。

◎コスト面

・工事期間中の教室の利用制限などといった調整がないため、工期の短縮となる。

　→仮設・リース期間の短縮。

・室内の養生が不要。

・室内の竣工清掃が不要。

・工事用の内部足場が不要。

・既存サッシは、特に改造なしでそのまま使用。

TOHOKU POSTANESİ EĞİTİM MERKEZİ

DEPREM GÜÇLENDİRME RENOVASYONU VE İNŞAATI

東北郵政研修センター耐震改修模様替その他工事

工事概要

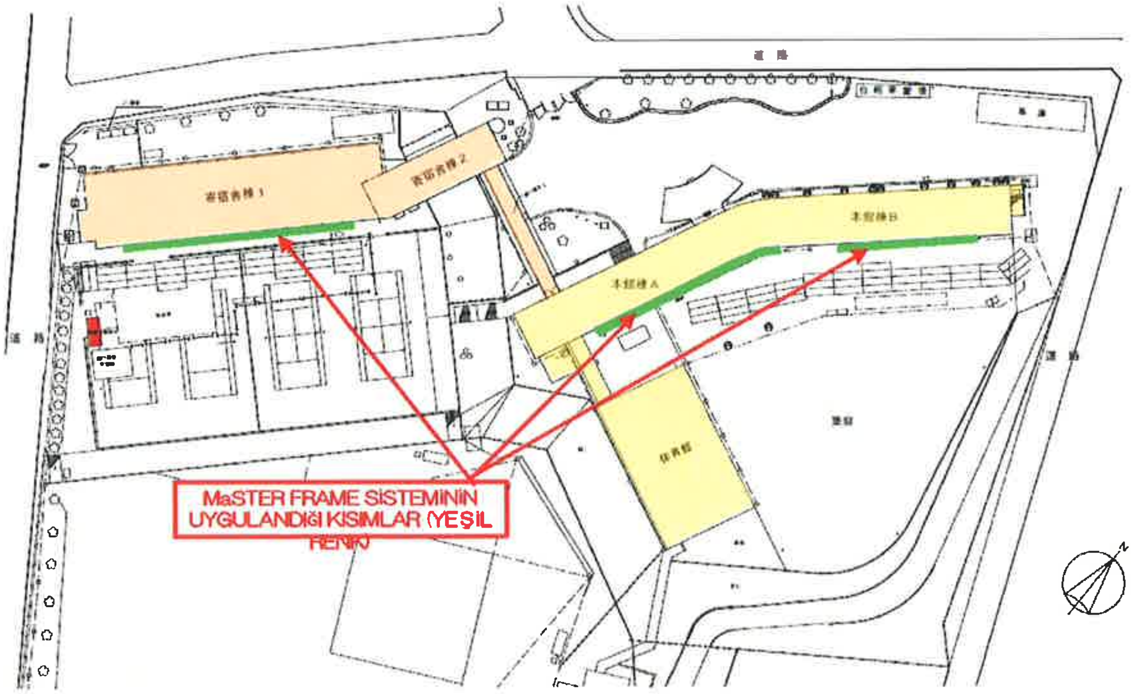
1 工事名称　東北郵政研修センター耐震改修模様替その他工事
2 工事場所　宮城県仙台市太白区八木山本町2-11-1
3 工事建物名称　東北郵政研修センター
4 建物概要

本館棟A	鉄筋コンクリート造	地下1階地上4階	延床面積	2,748㎡
本館棟B	鉄筋コンクリート造	地上4階	延床面積	1,831㎡
寄宿舎棟1	鉄筋コンクリート造	地上5階	延床面積	3,325㎡
寄宿舎棟2	鉄筋コンクリート造	地上4階	延床面積	643㎡

5 工期　自：平成26年1月9日
至：平成25年8月10日
6 発注者　日本郵便株式会社
7 設計監理者　日本郵政株式会社　東北施設センター
8 請負者　前田建設工業株式会社東北支店
宮城県仙台市青葉区二日町4番11号
TEL:022－225－8336
常務執行役員支店長　青木　敏久
9 施工管理　前田建設工業株式会社東北支店
宮城県仙台市青葉区二日町4番11号
TEL:022－225－8336
監理技術者：後藤　純
現場代理人：後藤　諠
建築職員：嵩井　英伸
建築職員　佐々木　敏治
10 工事概要
本館棟　耐震補強外付けフレーム工事
内部耐震補強構造躯体工事
内部耐震補強鉄骨フレーム取付工事
内外部災害被害調査及び修理復旧工事
建築工事に関係する設備施設　撤去復旧工事

寄宿舎棟　耐震補強外付けフレーム工事
内部耐震補強構造躯体工事
建築工事に関係する設備施設　撤去復旧工事

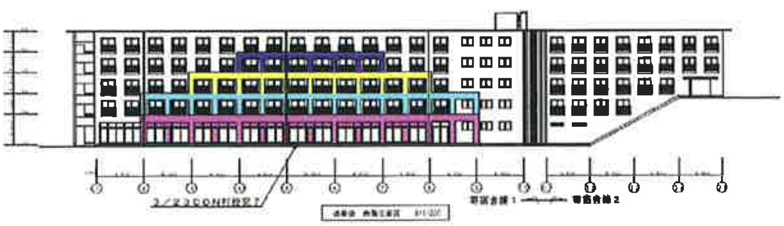
両棟　工事使用影響部の外構復旧・更新工事



YERLEŞİM PLANI

Ana Bina

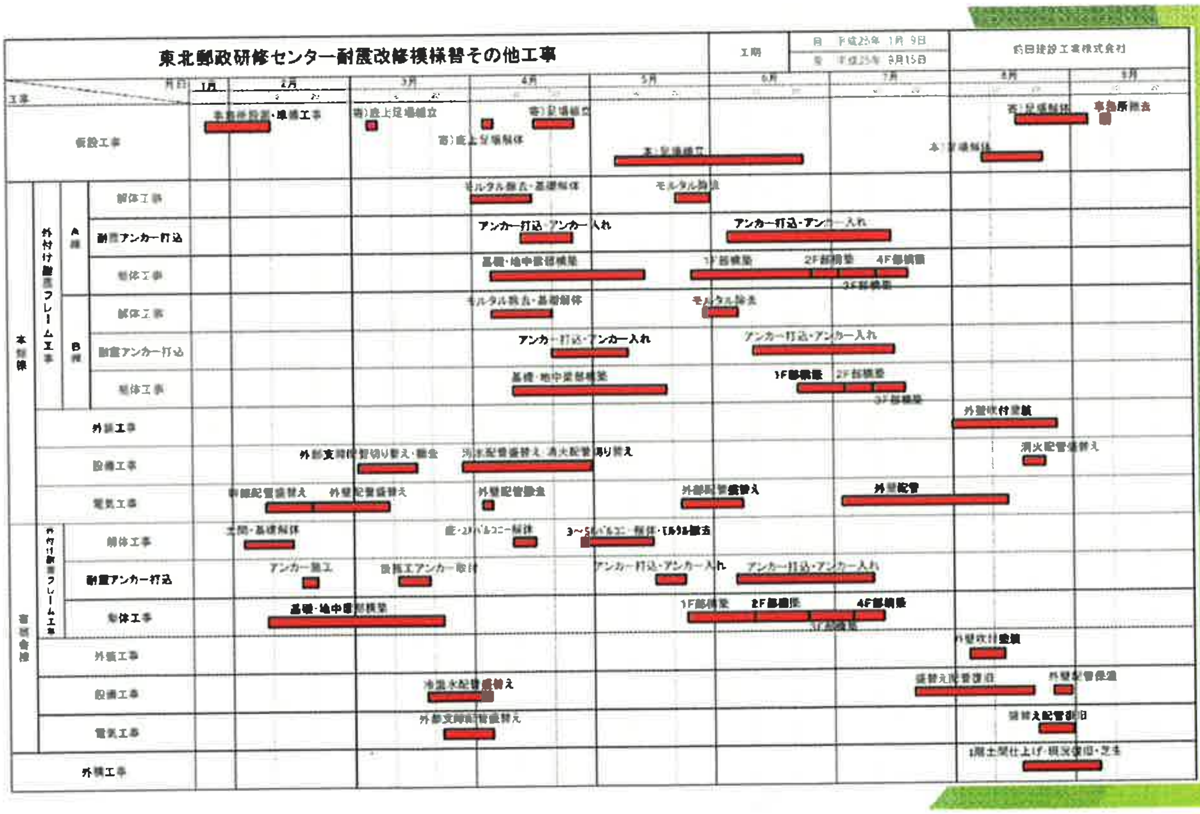
Yatakhane/Yurt Binası



Ana Bina ve Yatakhane/Yurt Binası MaSTER FRAME® Çerçeveleri

MaSTER FRAME® Uygulama Akış Şeması

- Yapı iskelesi kurulumu (Scaffolding Work)
- Mevcut (yapıda) donatı yerlerinin belirlenmesi
- Disk-Ankraj uygulanacak yerlerin belirlenmesi
- Disk-Ankraj deliği (karot) açılması ve ankrajların montajı
- Dış çerçeve için donatıların montajı
- Ankraj tijlerinin montajı (vidalanması)
- Kalıpların hazırlanması
- Betonun dökülmesi
- Kalıpların sökülmesi
- Sıva uygulaması (plastering work)
- Çatlakların kalafatlanması Joint Caulking ?
- Dış yüzey ince işler
- İskelenin sökülmesi



Uygulama fotoğrafları -1


İskele Kurulumu (Yatılı bina)


İskele Kurulumu (Ana bina)


Mevcut yapıdaki donatı yerlerinin belirlenmesi


Ankraj uygulanacak yerlerin belirlenmesi


Disk-Ankraj i ç in karot uygulaması


Disk-Ankraj' ların montajı

Uygulama fotoğrafları -2


Disk-Ankraj (montaj sonrası)


Kolon donatılarının hazırlanması


Kolon donatılarının yerle ş tirilmesi


Kalıbın yerle ş tirilmesi (kiri ş altı)


Kiri ş donatılarının montajı


Kiri ş donatılarının montajı (tamamlanmı ş)

Uygulama fotoğrafları-3

Disk-Ankraj tijlerinin motajı (vidalanması)

Kalıp işleminin tamamlanması

Beton dökümü

Kalıpların sökülmesi

Sıva İşlemi

Dış yüzey ince işleri (boya

Ana Bina

Güçlendirme Öncesi

Güçlendirme Sonrası

Yatakhane / Yurt Binası

Güçlendirme Öncesi

Güçlendirme Sonrası

MaSTER FRAME Sisteminin

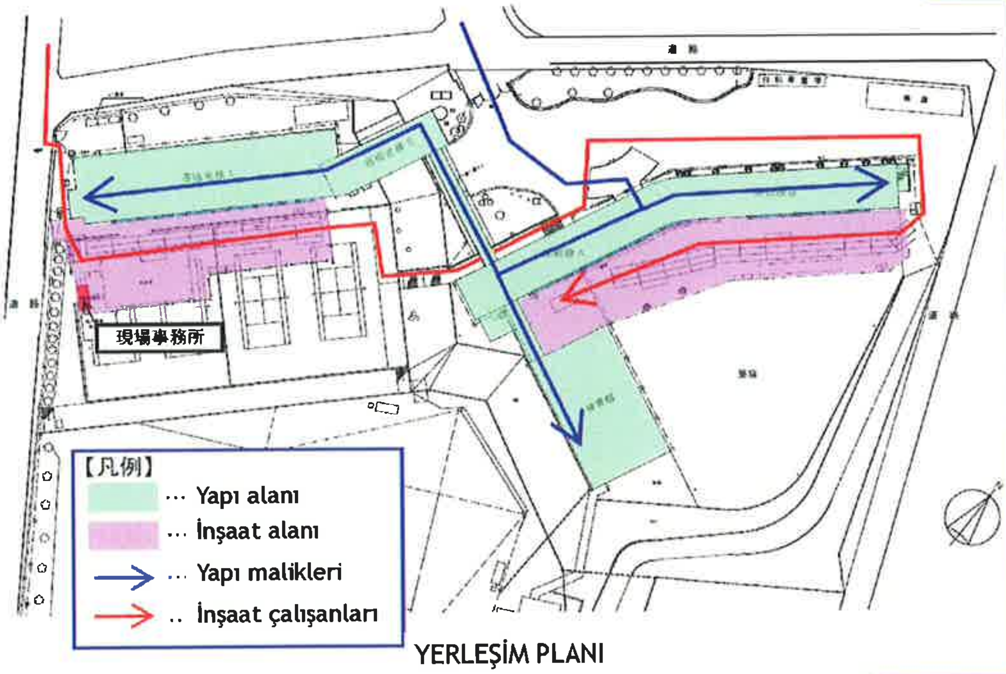
◎ Çevresel

- Tamamen yapı dışından uygulama yapılmakta olup, yapının kullanımını etkilememektedir,
- Uygulama esnasında mevcut yapı işleyişi/içinin durumu muhafaza edilebilmektedir.

Ana Bina Sınıfı

Yatakhane/Yurt Binası Oda İçi

- Yapı malikleri (kullanıcılar) ile inşaat çalışanlarının çalışma alanları birbirinden ayrılabilmektedir



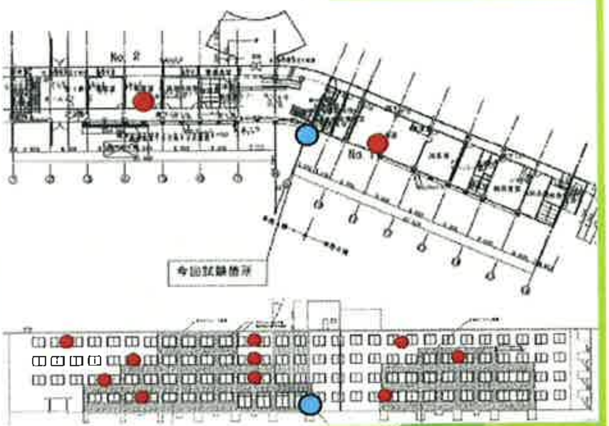
YERLEŞİM PLANI

- Ankraj uygulaması (sessis uygulama), donatı montaj çalışması esnasında çıkan ses yapı içinden hemen hemen hissedilmemekte, inşaat uygulama sürecinde sınıf/odaların **kullanımı kısıtlanmamaktadır**

No.	測定部位	棟	作業内容: モルタル撤去 – カッター入れ – 騒音測定レベル (平均)db	カッター入れ – 感覚判定 ○ × △	モルタルはつり – 騒音測定レベル (平均)db	モルタルはつり – 感覚判定 ○ × △	アンカー打ち込み – ハンマードリル – 騒音測定レベル (平均)db	ハンマードリル – 感覚判定 ○ × △	サイレント工法 – 騒音測定レベル (平均)db	サイレント工法 – 感覚判定 ○ × △
1	1F総務部	B	64	○	54	○	61	○	※	○
2	1F会議室	A	43	○	52	○	54	○	40	○
3	2F郵便端末機械室	A	66	△	60	△	63	△	–	–
4	2F貯金端末教室	A	50	○	57	△	48	△	–	–
5	3F302教室	A	56	△	59	△	52	○	–	–
6	[illegible]	A	48	○	55	○	44	○	38	○
7	3F合同教室	B	47	○	55	○	47	○	–	–
8	4F401教室	A	58	×	58	×	54	△	–	–
9	4F402教室	A	56	△	51	○	49	○	–	–
10	4F403教室	A	51	△	48	○	47	○	–	–
11	4F404教室	A	45	○	48	○	40	○	–	–
12	4Fさわやか郵便局	B	56	△	53	○	54	○	–	–
13	4F講堂	B	44	○	46	○	44	○	–	–
14	3F301教室	A	–	–	–	–	62	△	–	–
15	1F男子便所	B	78	×	91	×	87	×	63	△

◎ 測定は、1箇所10秒程度で行い、その間の平均db記入
◎ 感覚は、実習や業務に対しての影響度合いを記入

※ …該当騒音以外の暗騒音(話し声、物音)の方が騒音レベルが高い為、測定不能
○ (青) …特に影響なし
△ (黄) …短時間、マイク使用なら支障なし
× (赤) …研修や業務が出来ない
○ (緑) …業務は可能



- İnşaat uygulama esnasında dışarıdan sadece ‘yeşil koruma filesi’ kullanılmakta olup, odalar pencerelerden yeteri kadar güneş ışığı almaktadır.

◎Maliyet

- Uygulama esnasında odaların/sınıfların kullanımı kısıtlanmadığından inşaat süresi kısalmaktadır.

    →Konteyner/Kiralama süresinin kısalması

- Yapı içine bakım gerekmemektedir (No curing is needed in the rooms)
- Yapı içinde inşaat sonrası temizlik gerekmemektedir
- İnşaat için gerekli iskele gerekmemektedir (yapı içinde)
- Mevcut pencere çerçeveleri, yenileme gerekmeden kullanıma devam edilmektedir

ICI Integrative Center

Incubation × Cultivation × Innovation

Maeda Corporation
Technical Research Institute

Version E-r1.1

1-1. New Maeda Technical vision

MAEDA is the main component of society.
Creating a comprehensive network that combines technologies, the environment, Community and culture・art together with its network members, through business infrastructure system, we become a CSV special company = social problem solution contractor to undertake various social issues under the market economy.

1-2. New Hub to be SPSC

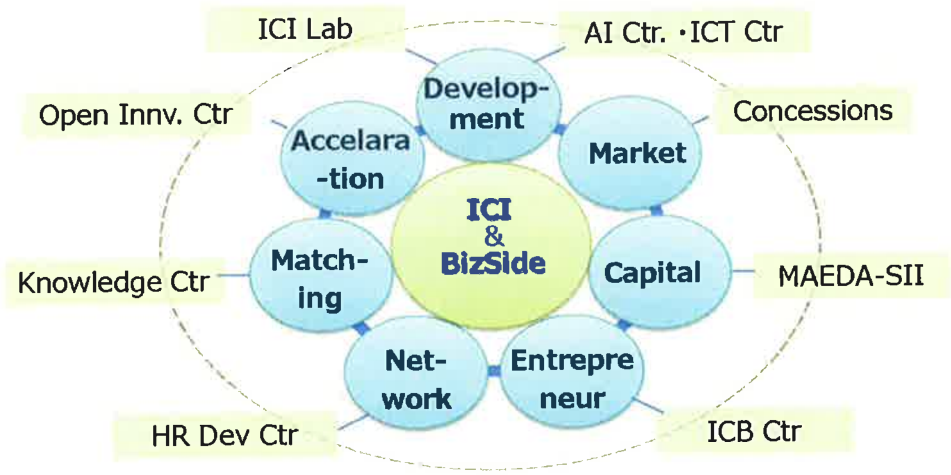
In order for MAEDA to become a Social Problem Solution Contractor, here is a new Hub to cultivate "value creation" and "human resource development".

Everything for social implementation of venture technology and ideas is all on one stop

Japan's first integrated innovation platform

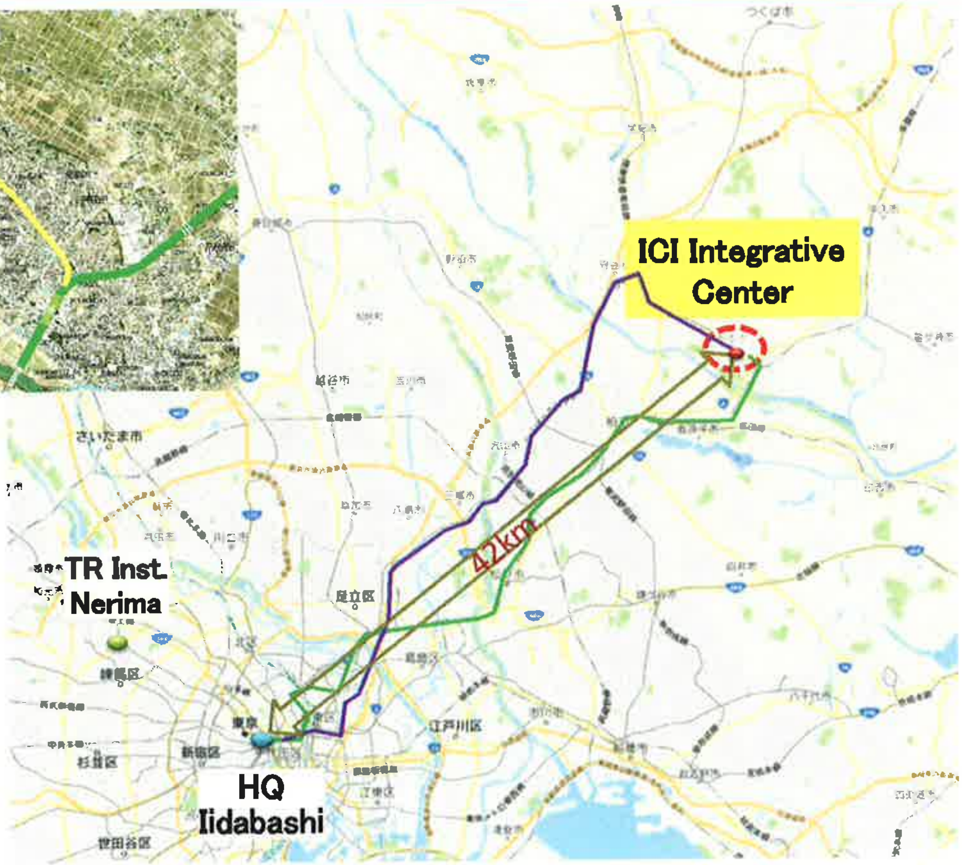
ICI Integrative Center

Incubation × Cultivation × Innovation



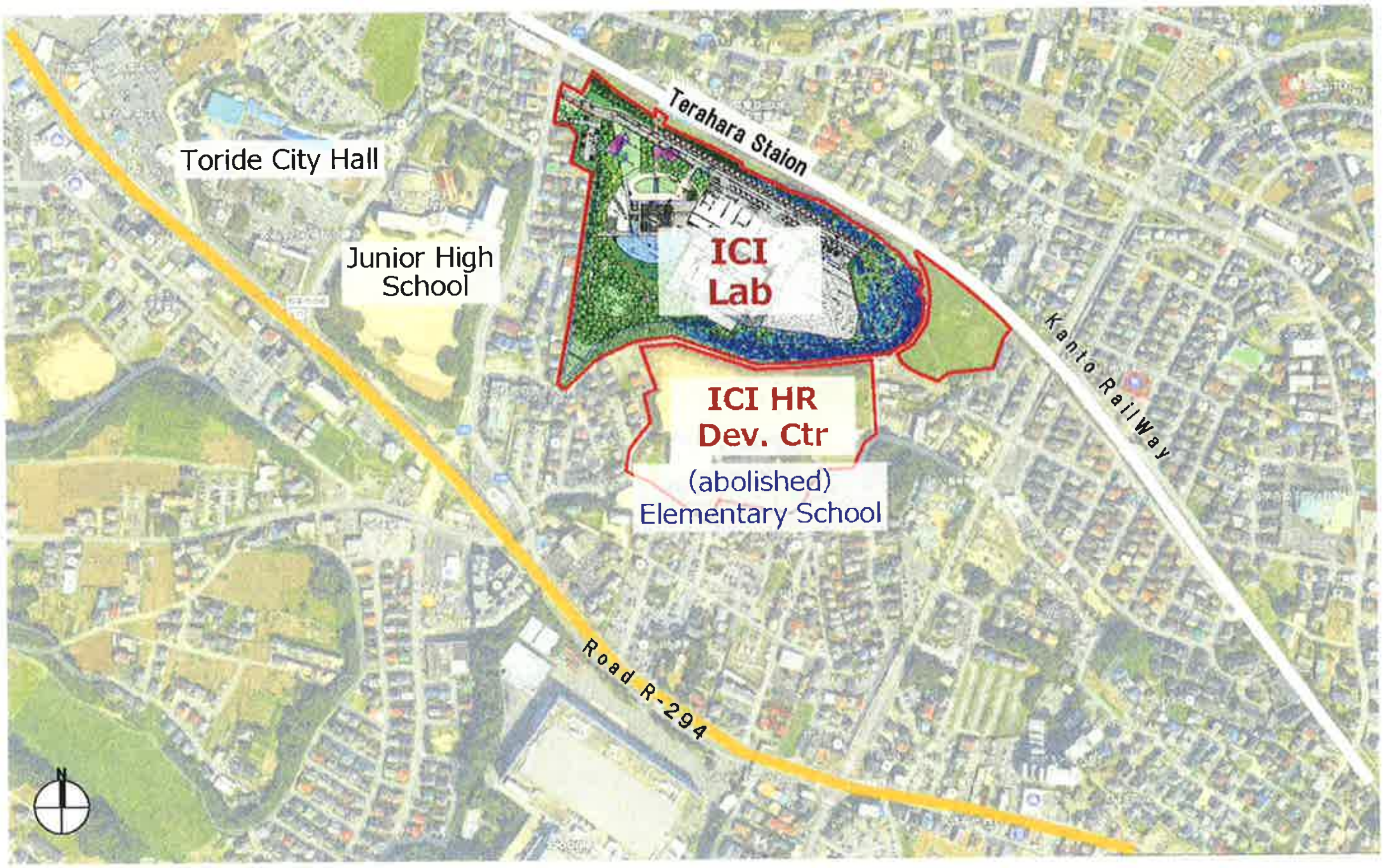
1-3. Location & Access

Area map



Access: About 1hr 15min by Train

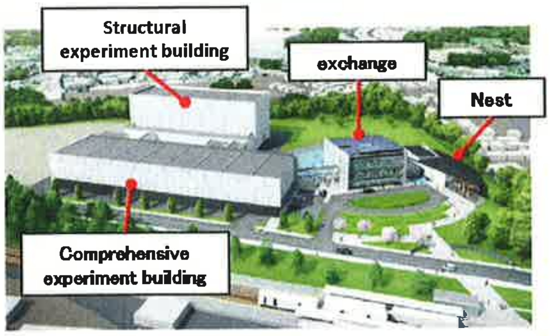
1-4. ICI Integrative Center (Toride City, Ibaraki)



1-5. ICI Integrative Center facilities

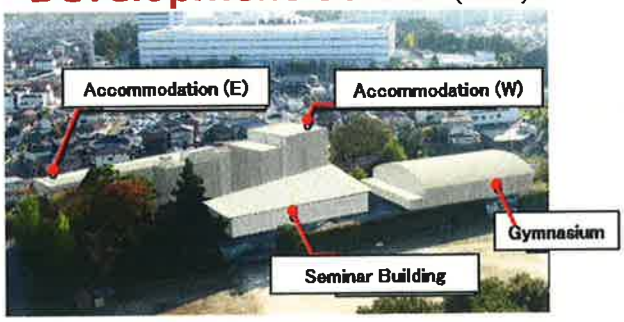
・The ICI Integrated Center consists of two areas, **ICI Lab** and **ICI Human Resources Development Center** (TBD).

ICI Lab



Incubation of Startup
Cultivation of Seed Techs
Innovation by Open Innovation

ICI Human Resources Development Center (TBD)



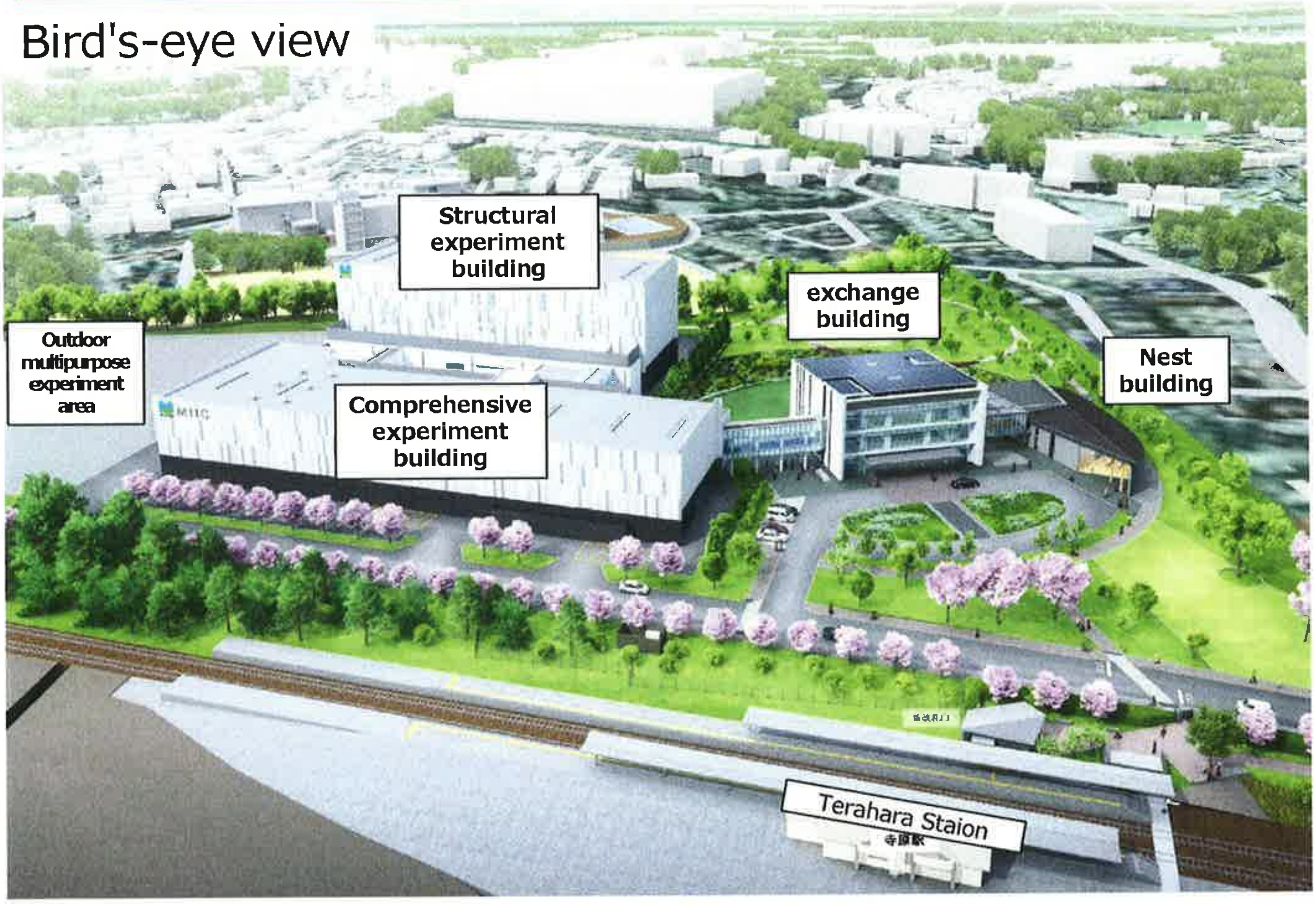
Incubation of CSV mind
Cultivation of talent and ability
Innovation of Various networks

Incubation × Cultivation × Innovation

1-6. ICI Lab

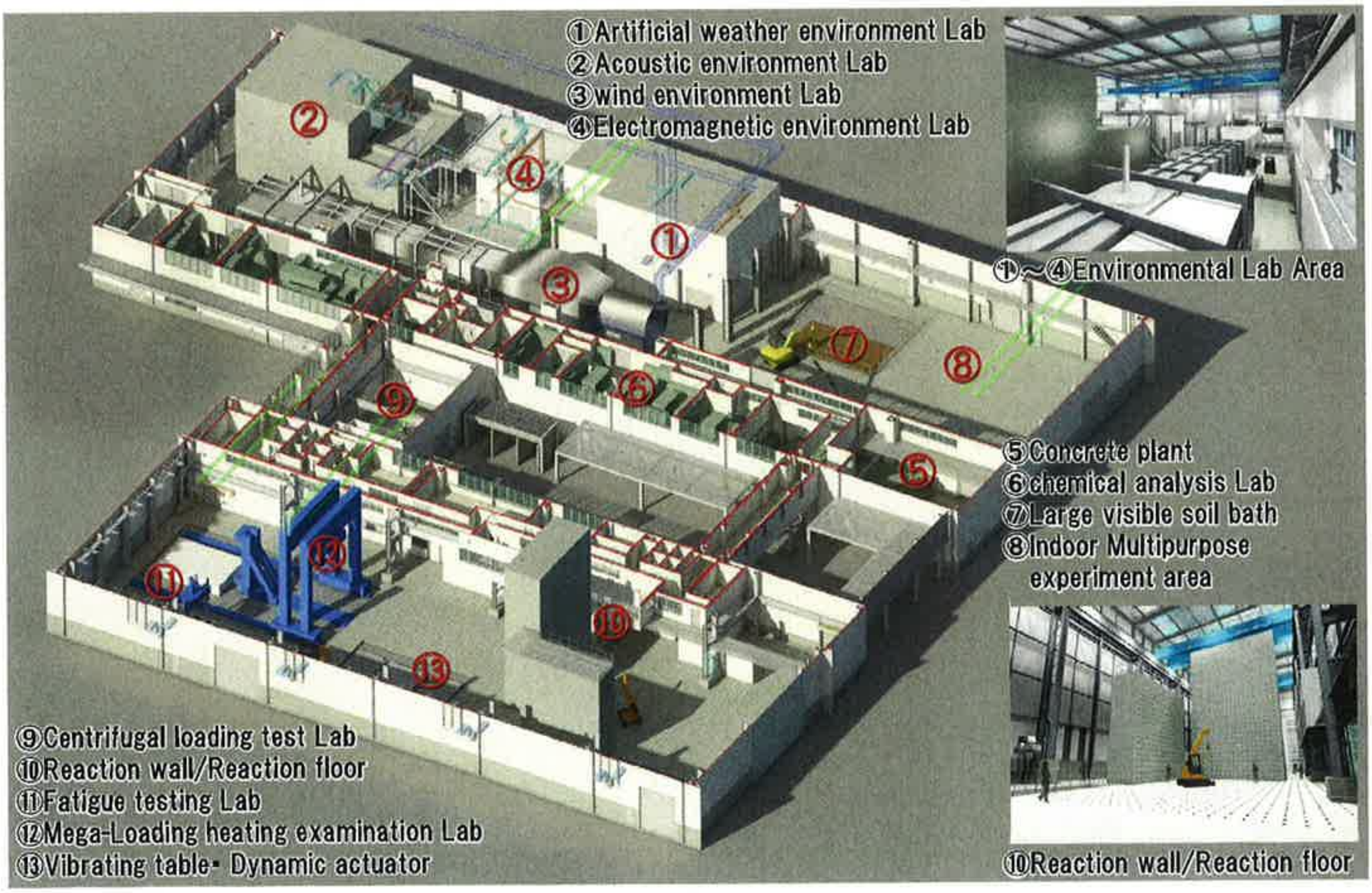
7

Bird's-eye view



1-7. Experiment building

8

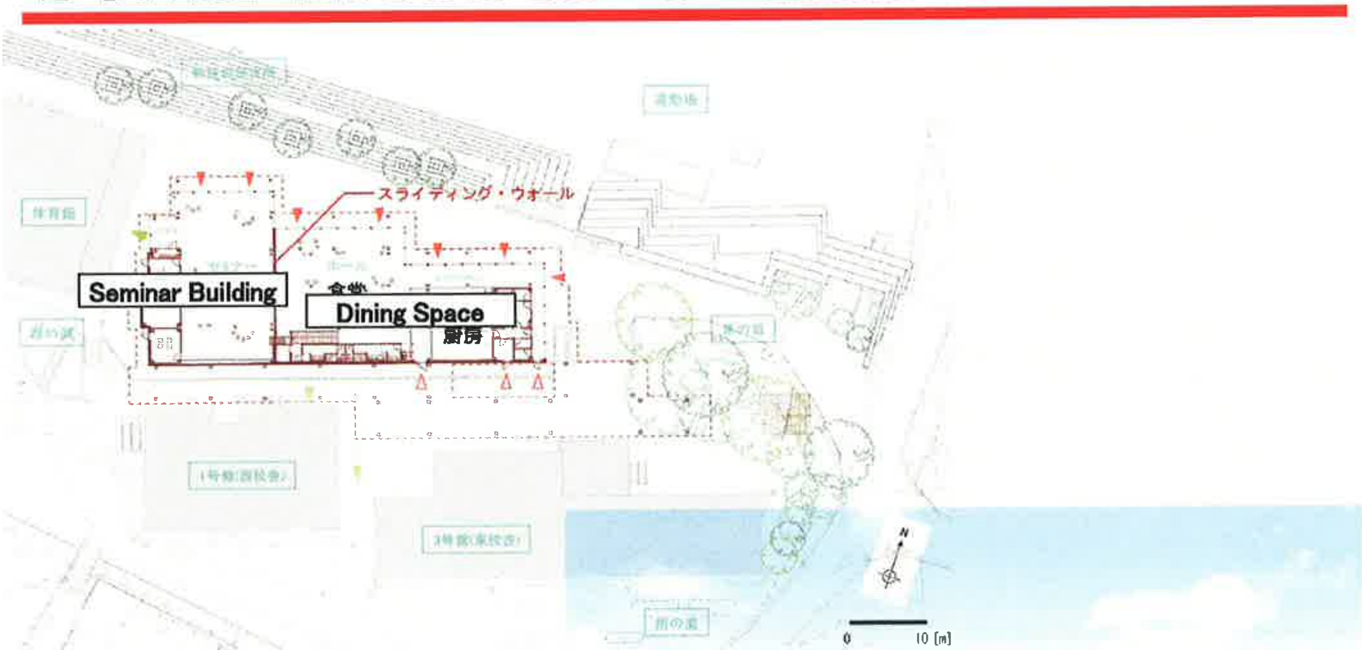


1-8. ICI Human Resources Development Center (TBD) 9

・This facility is the place to cultivate human resources that can contribute to creation of new value to startups, society and economy based on diverse networks intentionally adding different fields such as culture and art to the knowledge network, such as fusion of Tokyo University of the Arts and local government.

・ Not only training, but through cultivating Open Innovation talents, a network of Open Innovation implemented, and the exchange and the most-advanced living style here, it will be a platform that creates new value.

1-9. ICI HR Dev. Ctr　Sectional view 10



＞下層階

1-10. ICI HR Dev. Ctr Accommodation

> BASE Image

> CARA Image

〔測定項目〕

右表に示す各解体工具を、個別に稼動した際の

・騒音;空気伝播音等価騒音レベル(dBA)

・振動;体感振動レベル(dB)　等を、

施工箇所(発音源)および近隣住戸にて測定しました。

あわせて非稼動時の暗騒音、暗振動も測定しました。

工具の分類	測定対象工具	稼動位置
打撃系工具 コンクリートに打撃を加えて、はつる工具類。	① ハンドブレーカー	共用 階段室
	② 電動ブレーカー	
	③ ウォータージェット	
回転系工具 刃先を回転させ、躯体を切断する工具類。	④ コンクリートカッター	
	ダイヤーソー	
	⑤ ウォールソー	
	⑥ ダイヤモンドコアドリル	2階から 3階に至る 中間 踊り場
	[illegible]	
	⑦ ハンマードリル	
ニブラー系工具 コンクリートを引っ張りちぎる工具類。	⑧ 解体用ニブラー	
	⑨ ハンドクラッシャー	
その他	電動グラインダー	
	コンプレッサー	[illegible]
	モルタルスプリッター	住戸内 305号室
	ケレン棒	
	[illegible]	

⑥ ダイヤモンドコアドリル　(回転系)

●円筒状のダイヤモンドブレードにより、躯体を穿孔する工具。設備スリーブの新設、大割時の吊元穴の新設等、幅広く多用されています。

●ブレードの発熱抑制、粉塵の飛散防止のため、一般に冷却水を必要とします。

●電源　100～200V

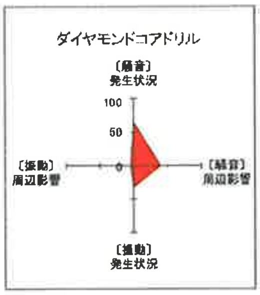
円筒形の
ダイヤモンドブレード

〔騒音〕 等価騒音レベル(dBA)

1	2	3	4	5	6
44.8	44	43	51.9	59.3	
43.7	48.2	47.3	56.0	[illegible]	[illegible]
47.8	47	46	55.3	70.4	
48.2	47	46	54.8	60.8	

〔振動〕 体感振動の増加量⊿(dB)

1	2	3	4	5	6
5.3	2	-1	5.0	2.3	
8.7	2.7	-0.4	6.4	4.4	12.2
8.5	2	-1	5.8	1.3	
12.6	1	-1	5.8	3.4	



⑦ ハンマードリル(大)　(回転系)

●尖頭を回転させ、小さな穴を開けるための工具です。仮設機材の一時固定やあと施工アンカー打込み等、改修工事において多用されています。

●電源　100V

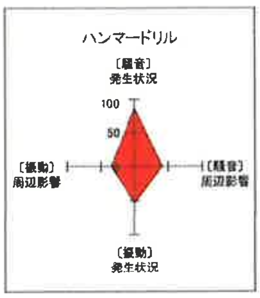
ハンマードリル
(上が小、下が大)

〔騒音〕 等価騒音レベル(dBA)

1	2	3	4	5	6
42.5	44	47	61.0	71.5	
41.1	44.0	49.5	63.2	[illegible]	[illegible]
43.1	44	48	61.7	78.3	
43.7	42	48	59.8	69.8	

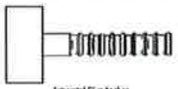
〔振動〕 体感振動の増加量⊿(dB)

1	2	3	4	5	6
3.7	5	10	7.3	14.9	
9.3	1.6	7.2	4.8	18.8	20.3
3.3	-1	4	1.6	13.3	
10.2	-2	4	1.7	11.7	

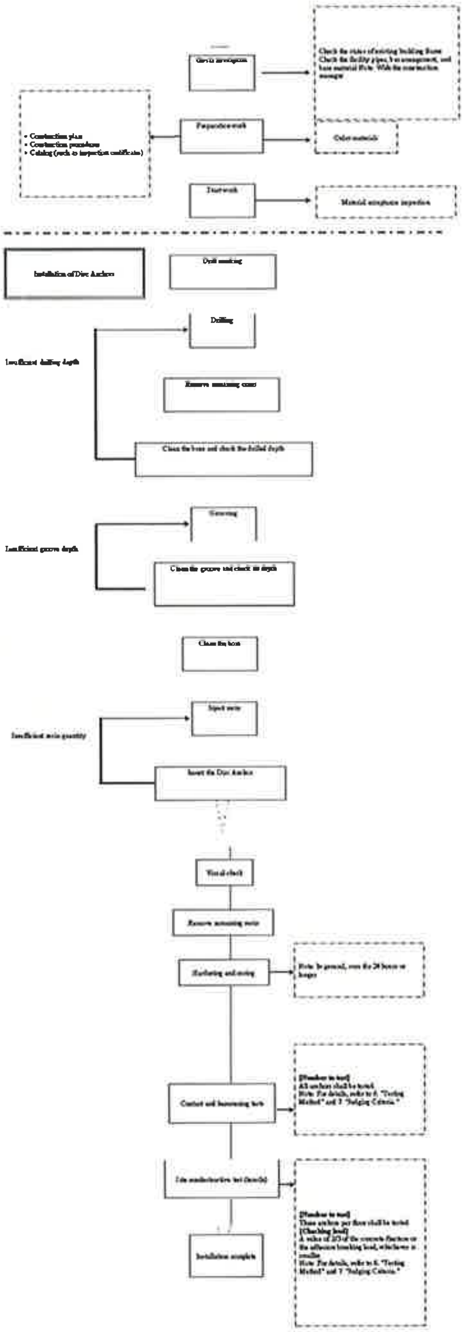


DISC-ANCHOR APPLICATION FLOW

MeSTER Disk-Ankraj (Integrated Type)



MeSTER Disk-Ankraj (Integrated Type)



PREPERATION FOR DISC ANCHOR INSTALLATION

INSTALLATION OF DISC-ANCHOR

COMPANY BROCHURE

MAEDA

OUR INNOVATION

Strategy of Innovating the Future

Sustainable Economic Development Required for the Future of Mankind and the Earth

Further economic activities are being conducted around the world in the face of a wide array of environmental challenges such as global drought, local heavy rain, diminishing tropical rain forests, and increasing endangered species. Moreover, while competition for resources and food is gaining speed in developed countries, problems associated with hygiene, food, and education, due in part to poverty, have risen in developing countries.

At the same time, Japan is being called on to rebuild social infrastructure on all aspects in preparation for the advent of lower birth rates combined with an aging population and a mature society. On top of these, responding to problems to prevent or reduce disasters and energy problems in the wake of the Great East Japan Earthquake and Tsunami in 2011 is yet another urgent issue to be addressed. It goes without saying that all industries and companies are being required to make efforts for sustainable economic development right now.

To Become an Innovator that Changes Japan's Infrastructure Projects through Maintaining and Further Bolstering the Core Business

Maeda Corporation aims to become a company that boosts the values it provides to society in a sustainable manner. Our foundation is the construction business, i.e., its core business, and the driving force is its construction performance due to the combination of dependable engineering, marketing, design, and job site management expertise. The company will hold fast to its disciplined stance when accepting contracts, which has been the basis of our sound business management, and will strive to maintain and further bolster the core business.

With these qualities as its strength, Maeda is working on an innovative initiative to expand its core business into other areas of business, thereby enabling it to undertake infrastructure projects from start to finish. As an innovator establishing a new business stage, we are determined to devote ourselves to achieving sustainable growth through "CSV (creating shared value) management" underpinned by "de-contracting," "globalization," and "corporate social responsibility (CSR) and environmentally considerate management."

PROGRESS FROM A CONTRACT

Sendai International Airport

A toll road project in Aichi Prefecture

"De-contracting" – a New Form of the Construction Business Opened up by Knowledge Gained from Construction Experience

Economic Depression in the late 20th Century that Forced the Conversion of a Business Model

An economic depression that Europe and the United States had been experiencing since the late 20th century likewise had a great impact on the construction industry; in consequence, companies operating there were forced to review their conventional business models and convert them drastically.

The waves of depression began spilling over to Japan in time. The business environment became increasingly severe. Japanese construction companies were pressed to promptly come up with measures to weather such a harsh era.

From Contractor to "Contractor and Concessioner"

In anticipation of the spillover effect into Japan from the Western economic depression, Maeda paid attention to concession business that already had a good track record in various areas in Europe. Under the concession system, a private-sector business, entrusted to operate public facilities, builds, operates, maintains, and renovates the facilities. It also raises funds on its own and recovers funds invested through collecting fees.

Based on this approach, Maeda began working on a business model, which we call "de-contracting," and, with a strong will to create a business, Maeda morphed from a company that solely wins a contract to a company that wins a contract and operates all aspects of the project. In 2014, Maeda established a joint venture with Macquarie Capital, the investment banking unit of Australia's global financial group Macquarie Group Limited. Entering into a partnership with Macquarie, which invests in, manages, and operates more than 100 infrastructure projects around the world, and by leveraging each other's strengths, Maeda broadens options in carrying out renewable electricity generation and infrastructure operation projects based on a concession contract.

■ Conceptual diagram of de-contracting: Conventional contracting and its upstream and downstream

AIM AT THE GLOBALIZATION

Upper Kotmale Hydroelectric Power Plant (Sri Lanka)

SUSTAINABLE COMPANY ACTIVITY

The Great Orange Tip, a butterfly for which Maeda Corp. Supports the Conservation Work (Taketomi Island, Okinawa Prefecture)

Renewable Electricity Generation and Concession Contracts – "De-contracting" Begins Moving

To meet the "de-contracting" target, Maeda has already embarked on a wide variety of projects. Since it has always been very important to Maeda to help solve environmental challenges, our efforts at renewable electricity generation led the way for these projects.

Maeda launched a mega solar power plant project with a maximum electric output of 2 MW in Tsukuba City, Ibaraki Prefecture. In addition, Maeda built the Goyozan photovoltaic power plant with a maximum electric output of 18 MW in Ofunato City, Iwate Prefecture and began selling electricity in 2015, thereby contributing to the reconstruction of the region affected by the 2011

Goyozan Photovoltaic Power Plant

Tohoku earthquake. Furthermore, off the coast of Shimonoseki, Yamaguchi Prefecture, Maeda is planning a 60 MW bottom-mounted offshore wind power generation project. In this way, it has moved its renewable electricity generation projects forward at a steady pace.

(Conceptual image) Yasuoka Offshore Wind Power Generation Project

Meanwhile, for the Sendai Airport project, the company's first concession contract in Japan, and the toll road project in Aichi Prefecture, we formed a consortium with other companies, which were granted the operating rights. Long-term operations by the private enterprise kicked off in 2016 for both projects.

In the future, Maeda plans to aggressively take part in concession contracts, such as toll roads, airports, and water and sewerage projects.

Sendai Airport (Image)

"Globalization" that Makes a Great Stride Thanks to Relationships of Trust with a Local Community

"Globalization" that is Made Possible by Relationships of Trust with a Local Community and the Spirit of "De-contracting"

In Japan, due to lower birth rates combined with an aging population, the domestic market is expected to decline in the long term. Given this, expanding into overseas markets and developing business there is a common challenge to the construction sector as a whole. Since Maeda opened its Hong Kong office in 1963, it has aggressively worked on expanding operations overseas. While gearing up for these changes in the Japanese market and in order to respond to the needs of countries centered on the ASEAN members that have shown noticeable growth, we will continue to vigorously promote our efforts at globalization from this point onward as well. What is essential to meet this goal is accumulated technical expertise based on the construction business and experience with "de-contracting." In the overseas market where fierce price competition is going on, we believe that what is called for is a construction company that can present value added on top of competitive pricing. Needless to say, a stance of going hand-in-hand with local companies and staff is another indispensable element in moving overseas business deployment forward.

By going hand-in-hand with the local community and earning its trust, Maeda will be able to understand the real needs of the project. With a perspective from not only a "contractor" but a "business operator," we will be able to offer overseas customers technology and satisfaction that surpass their expectations. We believe that this is the unique factor of Maeda for globalization that sets us apart from our competitors.

Aiming to Strengthen Our Business Footholds Further and Create New Ones

An on-site meeting between COFICO and our staff

Maeda is promoting efforts to bolster its business footholds that it has in 13 countries and regions around the world and to develop new ones. In Vietnam, with an eye toward expanding operations, we entered into business alliance agreements with the nation's leading construction firms, COFICO and VINA 6. Also in other regions, such as Turkey, we are promoting partnerships with local entities. On top of these, we set up bases in such countries as Myanmar and Mexico in an effort to accelerate our globalization initiative step by step.

"Environmentally Considerate Management" with Keeping the Earth, People, and Future in Mind, And Moving toward "CSV Management"

As a Company that Creates a Beautiful Earth, a Brilliant Future and People's Smiling Faces

While a new construction project provides people and society with safety, security and affluent lives, we must remember not only that it functions over a long period of time but also that it has a wide variety of impact on the natural environment. Based on this thought, in all areas of "business," "corporation," and "individuals," Maeda enhances its awareness of the environment, understands it, and puts it into practice. Considering the earth and society in the future and children who will play a central role then, Maeda has carried out social contribution activities, which have won accolades from all corners of the world, while appropriately following

The "Integrity Company Award" Presentation Ceremony

the company's policy, "a construction company trusted by the future."

Based on "Environmentally Considerate Management," Maeda Aims to Evolve into "CSV Management"

In April 2016, under the leadership of the new President Soji Maeda, the company embarked on an initiative to "become number one in CSV management," which resulted from evolving its philosophy of becoming a company that is responsible for both the global environment and the future society, under the motto of "becoming number one in environmentally considerate management."

Maeda Innovation Center, a new institute of technology, due to be completed in the fall of 2018 (Toride City, Ibaraki Prefecture)

Maeda will proactively address a wide array of social challenges and aim to sustainably develop and grow with society, while joining hands with all stakeholders, including customers and subcontractors, through the construction business, i.e., its core business, de-contracting, and other business activities.

— Starting Point —

From Dams to Urban Engineering and the Forefront of the Times – Maeda Takes a Step Forward beyond Civil Engineering

Kiso Fukushima No. 2 Hydroelectric Power Plant (Nagano)

Tagokura Dam (Fukushima)

Starts off as "Civil Engineering"

On January 8, 1919, Matabee Maeda Sr. started up a business as a civil engineering and construction firm in Kowashozu, Fukui Prefecture. It was reorganized into Maeda Corporation on November 6, 1946 and has continued operating up until now. We are pleased to say that we enjoy a solid reputation as a general construction company today. Undoubtedly, the road up to today was never smooth, however. Sweat and tears and great pleasure of all those who engaged in work and accomplished it through their efforts are engraved in the company's footprints.

A 17-year-old Girl Works as a Dayworker at the Kiso Fukushima No. 2 Hydroelectric Power Plant

The first project that Maeda undertook in 1919 was construction of the Kiso Fukushima No. 2 hydroelectric power plant to be built along the Otaki River flowing into the Kiso River in Nagano Prefecture.

The plant does not exist today but an episode has survived from those days of Matabee Maeda Sr.'s second daughter named Chiyono.

Back in those days, she, who was just 17 years old, is said to have handled every clerical work ranging from accounting to general affairs while working as a dayworker. She eventually married Shigeru Inoue, who later underpinned the company over a long period of time, and then continued to perform the pivotal role for Matabee Maeda Jr. and his senior vassals and finished her long life at the age of 85.

She fully demonstrated a knack for business in men's world and performed her role beautifully; her passion must have been handed down to women who work for Maeda today.

A crucial test for Matabee Maeda Jr. – The Tagokura Dam Touted as the Best in the Orient

In 1955, Maeda, which had been chalking up a track record in the construction of a wide variety of large-size dam power generation plants and railway subgrade, won a contract for building the Tagokura Dam planned in preparation for a possible emergency in the upstream of the Tadami River in Fukushima Prefecture.

Matabee Maeda Jr., who had taken the helm as president, faced a crucial test after being awarded the task of constructing the Tagokura Dam. With the dam height and length of 145 m and 462 m, respectively, and the dam volume of 1,978,000 m³, its power output capacity of 380 thousand kW exceeded that of the Sakuma Dam that was being built around the same time. The Tagokura Dam was touted as the largest scale in the Orient and became an object of envy among competitors vying for an order. Moreover, whereas the Sakuma Dam heavily relied on American technical guidance and large machinery, the Tagokura Dam was a major project of the century that Maeda tackled by making full use of American machinery along with technology of its own. For Matabee Maeda Jr., who picked up the baton from the predecessor, it was the project for which he must secure an order with his life.

Thanks to concerted efforts of the whole company, Maeda was awarded the task of constructing the Tagokura Dam, where Japan's first construction methods or records were established. For instance, the amount of concrete placement per day, which is one of the yardsticks for gravity dam construction, was 8,462 m³, the largest of all time. The amount of water leakage upon completion of the dam was 11 liters per minute at a full water level, which was an astonishing number meaning practically zero for a dam of this class. On top of those, the work procedure for electrical blasting established here has contributed not only to bringing innovative safety to subsequent civil engineering, mining, and quarrying projects but to drastically reducing future gunpowder disasters in the industry and saving countless precious human lives as well.

The Tagokura Dam saw the day of completion in time. Matabee Maeda Jr. ordered that the gigantic retaining wall holding a mountain by the entrance of the power plant be redone altogether by scraping, saying the finish was not decent enough, however. As if proving his "obsession" with details, the Tagokura Dam remains beautiful today as if it were wearing make-up. We would say that such an episode is yet another example that speaks of Maeda's stance of devoting all its passion to civil engineering.

— Starting Point —

Takase Dam (Nagano)
Completed in 1979. The dam height and length are 176 meters and 362 meters, respectively, with gross storage capacity of 76.2 million cubic meters. A rock-fill dam built under the Takase River Redevelopment Project.

On the surface of the rock-fill dam are 80 thousand cobblestones with a diameter of one meter or more placed one by one by a bulldozer.

Kap Shui Mun Bridge

Hikarigaoka J. CITY TOWER

Lampang-Chiang Mai Highway

Takase Dam, a Dream Dam Sprung from a "Dream Factory"

In 1971 Maeda undertook the construction of the Takase Dam, the largest-scale rock-fill dam for pumped-up hydroelectric power plant in the Orient.

At the construction site, where machinery several orders of magnitude heavier than that deployed when the Tagokura Dam or the Arimine Dam was constructed, the target embankment of as huge as 30,000 m³ a day had been met at a steady pace. Moreover, the operations of heavy machinery or the quality of embankment materials were managed via a computer network between the construction site and the head office while a maintenance shop equipped with a parts supply system was set up; it was just like a "dream factory" that appeared in the remote mountains.

The Takase Dam, which was completed in 1979, gives off a gentle aura typical of a rockfill dam even today. By the dam erected is a monument that says, "Constructed by Maeda Corporation," a proof that it embodied a dream of Matabee Maeda Jr.

Maeda, which has been trained and fostered through the construction of dams in this way, engaged in constructing the Seikan Tunnel when it comes to tunnels. In a wide variety of fields, such as the Honshu-Shikoku Bridge and the Trans-Tokyo Bay Highway, the company was involved in a large number of technically highly difficult national projects. When it comes to its business overseas, Maeda made a foray in Hong Kong in 1963 and handled the Kap Shui Mun Bridge, a motif on a local banknote, and the Stonecutters Bridge, a world-largest-scale cable-stayed bridge. It also engaged in constructing the Lampang-Chiang Mai Highway in Thailand in 1965. Thereby, Maeda established an impregnable position of "Maeda, the Powerhouse in Civil Engineering."

Maeda Moves on to High-rise Buildings and Maeda of the 21st Century

Meanwhile, Maeda's history of architecture started with the construction of administrative buildings for dams and apartment buildings by public housing corporations. In 1960 the company set up the architecture department and won an order for a big project of Tokiwadaira Danchi (public housing complex) the same year. In the 1980s it embarked on projects in the private sector in earnest, expanding the scope of undertakings into power generation plants, factories, housing complexes, and commercial facilities.

In 1986 Maeda set out to develop high-rise reinforced concrete (RC) buildings. In 1988 review was completed by the High-Rise Steel Reinforced Concrete Structure Technology Committee of the Building Center of Japan and in the meantime, the company established the methods for structural design, material performance assessment, and construction. In the 1990s Maeda's first 21-story high-rise RC condominium, Lions Station Tower Higashi Sapporo, was completed in 1991. The company continued to broaden the range of its architectural technology into ultrahigh-rise buildings in Tennozu and Hikarigaoka in Tokyo and dozens thereafter. Maeda, which aggressively develops technology for designing and constructing RC structures, chalked up a track record in skyscrapers, such as a 200 meter-high twin tower in Kachidoki, in the 2000s, thereby establishing the MARC-H design and construction system for ultrahigh-rise RC housing complexes. It achieved rational construction thanks to precast concrete (PCa) main structures and high quality and durability at the same time. The company worked on the Park Court Chiyoda Fujimi The Tower project, which was completed in 2014, as the culmination of Maeda's PCa-based construction and spared no effort to inject its technical expertise. Through these efforts, Maeda has become the industry leader in the housing complex segment, including ultrahigh-rise RC structures, making its presence felt thoroughly in the architectural realm as well.

"Integrity, Willingness, Technology" – Matabee Maeda's Resolve has been Handed down from One Generation to Another

Since it was founded in 1919, Maeda has performed every single task earnestly and carefully with wisdom and determination up until today while keeping taking up challenges on both the technology and management fronts. The three words set forth in the corporate motto "Integrity, Willingness, Technology" reflects Matabee Maeda's resolve, which has remained unchanged since the company was awarded the first civil engineering contract for the Kiso Fukushima No. 2 Hydroelectric Power Plant, and its employees' firm determination with an eye toward the future, who are in the front line of today's civil engineering and construction arena.

Achievements

Each of these is a sign of trust.

Iidabashi Station West Exit Area Category 1 Urban Renewal Project (Chiyoda Ward, Tokyo)
The complex consists of three buildings: a 30-story office/commercial building, a 40-story residential building, and a three-story church building. Maeda undertook the design and construction of the office/commercial and residential buildings. Designed with the surrounding landscape in mind, the two functionally different towers both measure 150 meters high, creating a harmonious townscape.

Fukuoka Dome (currently, Fukuoka Yafuoku! Dome) (Fukuoka City, Fukuoka Pref.)
First and only baseball dome in Japan which has a retractable roof. The 12,000-ton heavy roof consists of three panels and fully opens or closes in approximately 20 minutes by rotating two of them right and left by 120 degrees.

Akebono Crystal Wing (Hanyu City, Saitama Pref.) (Won 44th BCS Prize)
Akebono Brake Industry's headquarters office at its Hanyu plant. It has a large column-less space of approximately 2,845 m² roomed by using 11 string beams with a length of 22 m.

Sumita Town Office (Sumita Town, Kesen District, Iwate Pref.) (Won 57th BCS Prize)
Purely wooden town office building constructed by making full use of locally sourced materials and locally manufactured and processed timber. It has advanced-design lens-shaped truss beams and load-bearing lattice walls while maintaining a traditional image of pure wooden architecture.

Riverwalk Kitakyushu (Kitakyushu City, Fukuoka Pref.)
The five elemental geometric buildings serve as a "symbol of hope for Kitakyushu City's prosperous future," in harmony with the surrounding environment. They were designed with an eye to forming a bustling space and creating an attractive town that matches the city center.

NTN Driveshaft Anderson New Plant
NTN Driveshaft Anderson, Inc. was established in 2015 as NTN's third Driveshaft manufacturing plant in the U.S. It is located in Anderson City, a suburb of Indianapolis, Indiana. They mainly manufacture CVJ (Constant Velocity Joint) for automobiles. The total floor area is 37,337 m².

Sumitomo Electric Sintered Components Mexico New Factory.
The plant is located in San Francisco de los Romo, Aguascalientes, Mexico. They manufacture Sintered parts for Automobiles. It was constructed as Design-Build and Joint Operation with GC PEASA. Total floor area is 7,500 m².

Hong Kong International Airport Terminal Building (Hong Kong)
Super-hub airport with an architectural area of as large as 516,000 m². It is recognized as one of the world's best airports and has consistently been among "the world's best airports" selected by a British aviation-related research firm.

Achievements

Heiwa Corporation Headquarters Building (Taito Ward, Tokyo)
Heiwa Corporation's new headquarters building, which was designed and constructed by Maeda. It has an edgy design with double-skin curtain walls so that it serves as a symbolic tower for the surrounding area of Ueno. It has 18 stories and a total floor area of 8,722 m².

BIG FRONT Hiroshima (Hiroshima City, Hiroshima Pref.)
Towering complex serving as a new landmark in front of the station. It consists of two buildings (one is 52-story and the other is ten-story), incorporating a condominium, a hotel, offices, and shops.

Otsuma Gakuin Educational Institution Otsuma Women's University Building H (Chiyoda Ward, Tokyo)
School building aimed at further expanding and improving the educational environment of the institution's Chiyoda campus, with an eye towards three "connections"—"connection to people," "connection to the environment," and "connection to the future." It is an eight-story two-basement building with lecture rooms, laboratories, computing rooms, study rooms with computers, researcher's rooms, etc.

Hyatt Regency Fukuoka (Fukuoka City, Fukuoka Pref.)
Hyatt Regency Fukuoka, basically designed by world-renowned Michael Graves, and urban complex facilities including office buildings. It received the 26th BCS Prize.

Hoshinoya Kyoto Ranbyoken Renovation (Kyoto City, Kyoto)
The renewal construction involved the remodeling of a venerable riverside inn with a view of the Katsura River in Kyoto's Arashiyama District, which is famous as the location of the Hozugawa River boat ride, transforming that inn into the Hoshinoya Kyoto premium inn.

Tokushima Prefectural Central Hospital (Tokushima City, Tokushima Pref.)
Construction of hospital facilities that serve as Tokushima Prefecture's medical infrastructure. The hospital has a seismically isolated structure to function as a disaster control center, and also has a rooftop heliport. It is a nine-story building with a total floor area of about 38,821 m² and 460 hospital beds.

Himonya Shopping Center (Meguro Ward, Tokyo)
One of Tokyo's largest-scale commercial facilities with a total floor area of 25,815 m². The building was fully renovated and now has a totally new and different exterior design.

Suntory Pepsico Central Greenfield Project
The plant is located in Dien Nam–Dien Ngoc Industrial Zone, Quang Nam Province, in the Central Part of Viet Nam close to Da Nang City. It manufactures Beverage Bottling and was constructed in January, 2017 as Design-Build by Maeda Vietnam Co., Ltd. The total floor area is 50,313 m².

Suzuki Motor Thailand Four Wheel Factory Project
The plant is Suzuki's first four wheel automobile manufacturing plant in Thailand facilitated with engine plant, press, welding, painting, and assembly. The plant is located in Hemaraj Eastern Seaboard Industry Estate, Rayong, Thailand. Total floor area is 65,962 m².

Achievements

Tokyo Bay Highway Umihotaru (Kisarazu City, Chiba Pref.)
Of the two artificial islands, Maeda took on the construction of Kisarazu Artificial Island (Umihotaru), along with the shield construction of the undersea tunnel from the island to the halfway point between the island and Kawasaki Artificial Island.

Seikan Tunnel (Fukushima Town, Matsumae District, Hokkaido)
The Seikan Tunnel, which is part of the Hokkaido Shinkansen line, lies 100 m below the seabed of Tsugaru Strait, the maximum depth of which is 140 m, and has a length of 53.85 km (undersea: 23.3 km; overland: 30.55 km). Maeda undertook the construction of the undersea tunnel in its Yoshioka section.

Misakaiki Dam (Minamiaiki Village, Minamisaku District, Nagano Pref.)
Maeda constructed the upper dam in a hydropower project (max 2,820,000 kW). It is an earth core, cut-off, fill-type dam with a dike height of 150 m, a dike top length of 444 m, a dike volume of 7,200,000 m³, and a total storage capacity of 19,170,000 m³.

MTR823A/A230 (Hong Kong)
Maeda constructed an approximately 2.5 km long section of the high-speed rail that connects between Hong Kong and China's mainland [illegible]. The section includes a TBM (tunnel boring machine) tunnel and open cuts. In addition, many supplementary facilities were constructed including Hong Kong's sole shelter station for emergency rescues, rail yards, and a control centre.

Suzu Wind Power Plant (Suzu City, Ishikawa Pref.)
Maeda was involved as an EPC (engineering, procurement, and construction) contractor in the development processes for 20 wind power generators ranging from research and design to procurement, transportation, and engineering and electrical works. They each have a total height of 98.95 m, a rotor diameter of 70.5 m, and a rated output of 1,500 kW.

Taipei's Subway Network Songshan Line CG590A (the Republic of China)
Construction of three stations and six tunnels located in the financial district in the downtown area in the largest construction section of the Taipei Metro Songshan Line. It won many awards including Taipei City's award for excellent construction site manager.

Ayutthaya Flood Prevention (Thailand)
Construction of floodgates in two locations, Hua Ro Canal and Kra Mang Canal, to the East side of the Pasak River in Ayutthaya, courtesy of a grant-in-aid from the Japanese Government. It includes the construction of an approximately 300 m long embankment on both sides of the river.

Stonecutters Bridge (Hong Kong)
One of the world's largest cable-stayed bridges, which links Stonecutters Island and Tsing Yi Island. The lengths of its side spans, main span, and total length are 289 m x 2, 1,018 m and 1,596 m, respectively, and it has two main bridge towers (298 m high above sea level).

Achievements

Katsushima Pump Station Inlet Pipeline (Shinagawa Ward, Tokyo)
Construction involving inlet pipelines in Tokyo's Katsushima pump station. Its objectives are to prevent inundation of the Tachiai River basin and improve the water quality of the Katsushima Canal. Slurry shield method, 900 m length, and 8,500 mm finished inner diameter.

Da Mi Hydropower Plant (Vietnam)
Vietnam's first large-scale hydropower plant. Maeda developed a rockfill dam with a dike volume of 3 million m³ and a power plant with a maximum output of 175 MW in the Da Mi River, a tributary stream of the La Nga River.

Upper Kotmale Hydropower Plant (Sri Lanka)
Sri Lanka's hydroelectric power station aimed at stably supplying electric power. Maeda constructed a concrete gravity dam with a storage capacity of about 800,000 m³, a 13 km long headrace tunnel, a hydraulic pipeline tunnel, and an underground power plant with a maximum output of 150,000 kW.

Toyomi Hydroelectric Power Plant Renewal (Aga Town, Higashikanbara District, Niigata Pref.)
The hydroelectric power plant, constructed on the left bank of the Agano River from 1927 to 1929, was extensively renovated to increase its maximum output from 56,400 kW to 61,700 kW by improving the efficiency of equipment while utilizing existing facilities such as the dam and fish passages.

Nagoya High-speed Rail (Nagoya City, Aichi Pref.)
The tunnel on high-speed rail route 4 was extended by 787 m from the Tagata Museum station to the Toyota station by multi-face shield tunneling (Note: DOT (Double-O-Tube) tunneling).

Hokuriku Shinkansen Line Hakusan Hantauchi Viaduct (Hakusan City, Ishikawa Pref.)
Construction of the viaduct between the points at distances of 335,250 km and 336,488 km from Takasaki (1,238 m long) on the Hokuriku Shinkansen line. Embankments, RC (reinforced concrete) rigid-framed viaduct, RC abutments, RC bridge piers, RC girders, PC (prestressed concrete) girders, and culverts were constructed.

Hokkaido Shinkansen Line Iida Viaduct (Hokuto City, Hokkaido)
Maeda constructed the viaduct between the points at distances of 145,454 km and 147,300 km from Shin Aomori (totaling 1,836 m in length), which is part of the new, approximately 28 km long, Hokkaido-side section of the Hokkaido Shinkansen line (Shin Aomori to Shin Hakodate).

Higashi-Kyushu Expressway Oshi Tunnel (Hyuga City, Miyazaki Pref.)
Mountain tunnel constructed by blasting excavation with a length of 387 m. People in the coastal areas of East Kyushu were waiting for its early opening because of their need to improve access to major cities in Kyushu. It was opened in March 16, 2014.

Kaikura Dam (Kawaminami Town, Koyu District, Miyazaki Pref.)
The concrete gravity dam was constructed in the Class A river Kiribaru-gawa for irrigation of dry fields. In the first phase of the construction, foundation excavation and preparatory dam construction were carried out, and in the second phase, the concrete body was mainly constructed. It has a dike height of 51.3 m, a dike volume of 230,000 m³, a basin area of 33.1 km², an inundation area of 11 ha, and a storage capacity of 2,[illegible] m³.

Corporate Motto, enacted in January 1968

"Integrity"

As long as a company remains in business, it has to produce a profit. However, focusing only on profit prevents the company from continuing. Only when the company has integrity and interacts with clients, will the business last and develop. Integrity is fundamental to a business.

"Willingness"

Work, it requires a strong self-discipline. Without confidence that we are the best in technology, pricing and scheduling and without willingness to push ourselves to overcome difficulties, any work could not be completed. The point is willingness. Willingness to work strengthens our minds and is indispensable to both our business and personal life.

"Technology"

Maeda features its technology. We are strongly hoping that our workmanship instantly reveals that the work was done by Maeda. It is our technology that others want to learn from Maeda and not that Maeda has learned from others. This is our advantage.

Founding Philosophy

Gaining customers' trust by doing a good job

Maeda's founding philosophy, which is also our policy on quality, is "Gaining customers' trust by doing a good job."
Establishing a relationship of trust with our customers and the society
as a result of our devotion to construction with integrity will pave the way to the next step.

Message from the President

The year 2019 will mark the centennial of the founding of Maeda.

The Japanese construction market is currently enjoying the greatest boom in the past quarter century. However, the market outlook is by no means reassuring. In the foreseeable future, market demand is likely to not only decline in quantity but also change in nature from new construction to maintenance and renovation. As a result, the construction market is expected to encounter a major turning point that has never been experienced before.

In view of the changing business environment, we have been exploring new possibilities in de-contracting while continuing ongoing efforts to increase the profitability of contractor business. At the same time, we have been aiming to become a corporate entity responsible to both the global environment and the society in the future, with the corporate goal of becoming the best environmentally considerate company in the world.

With the centennial milestone drawing near and in anticipation of the upcoming major changes in the market environment, we are renewing our determination to increase our efforts.

Under our current management plan that kicked off in April 2016, we have set three new goals, namely, becoming number one in profitability, de-contracting, and CSV (creating shared value) management.

We will strive to increase productivity in every single department to meet the goal of becoming number one in profitability.

We will upgrade ongoing efforts in the areas of renewable energy business and concession business to become number one in de-connecting.

Through such business activities, we will tackle a wide array of social challenges in cooperation with all stakeholders, including customers and affiliated companies, in order to achieve CSV management that realizes sustainable growth.

As we complete our first 100 years and start a new century of service, we firmly believe that we need to seriously think about what we should do now, i.e. effective strategies and their implementation.

Your continued guidance and support would be greatly appreciated.

Soji Maeda
President

Give thanks for the 100 Years, Make a Vow in the 101st Year

Maeda was founded by Matabee Maeda Sr.
as a civil engineering firm in Kowashozu, Fukui Prefecture in 1919.
In 1946, it was incorporated as Maeda Corporation
and has continued operations to this day.
During this time period,
it was involved in the construction of the world's longest and deepest undersea tunnel,
the largest rockfill dam in the Asia, Japan's first retractable roof dome,
an super high-rise housing complex with the most stories in Japan,
and entered into a concession contract
with Japan's first Private Finance Initiative (PFI), to name but a few.
It has continued to take up a wide variety of challenges in line with the needs of the times.
Maeda will mark the centennial of its founding in 2019.
With our profound gratitude to all stakeholders whom we have met since our inception
and our corporate motto "Integrity, Willingness, Technology" in mind,
we are determined to hand down our history of challenges
and take the first step forward with an eye toward the new century.

■ Maeda Memorial Hall Location

Maeda Corporation
Head Office
2-10-2, Fujimi Chiyoda-ku, Tokyo 102-8151 Japan Tel:(81)-3-3265-5551
http://www.maeda.co.jp/

2017.03

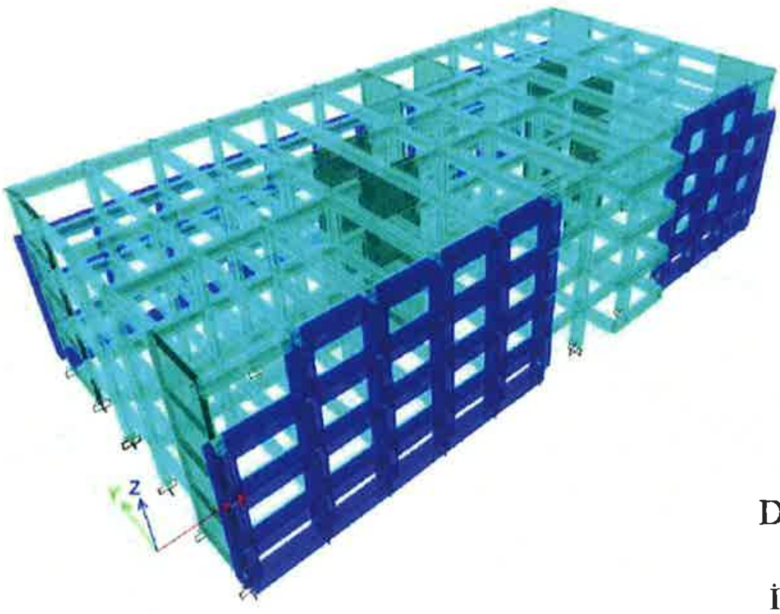
添付２　タスクフォース報告書
イスタンブール工科大学による検証報告（トルコ語）

İSTANBUL TEKNİK ÜNİVERSİTESİ
İNŞAAT FAKÜLTESİ
İnşaat Mühendisliği Bölümü
34469 Maslak, İstanbul

Tarih ve sayı: ....2019/...

MaSTER FRAME® KULLANARAK TİPİK OKUL BİNASI GÜÇLENDİRME RAPORU'NUN GÜNCEL YÖNTEM VE ŞARTNAMELERE UYGUNLUĞU HAKKINDA TEKNİK RAPOR

Bu rapor İstanbul Teknik Üniversitesi Döner Sermaye İşletmesi Yönetmeliği'ne uygun olarak hazırlanmıştır.



Hazırlayanlar

Prof. Dr. Kadir Güler
Dr.Öğr.Üyesi Fatih Sütcü

İstanbul Teknik Üniversitesi,
İnşaat Fakültesi,
İnşaat Mühendisliği Bölümü

Mart 2019

İTÜ

İSTANBUL TEKNİK ÜNİVERSİTESİ

İNŞAAT FAKÜLTESİ

İnşaat Mühendisliği Bölümü

34469 Maslak, İstanbul

Tarih ve sayı: ….2019/…

"MaSTER FRAME® KULLANARAK TİPİK OKUL BİNASI GÜÇLENDİRME RAPORU'NUN GÜNCEL YÖNTEM VE ŞARTNAMELERE UYGUNLUĞU HAKKINDA TEKNİK RAPOR

1. KONU

GKMC İnşaat ve Danışmanlık A.Ş., İstanbul Teknik Üniversitesi İnşaat Fakültesi'ne 15 Nisan 2019 tarihli dilekçe ile başvurarak, Japonya'da kullanılan MaSTER FRAME® güçlendirme tekniğinin Türkiye'deki bazı tipik okul binalarının depreme karşı güçlendirilmesi konusunda PROMER Müş. Müh. A.Ş. tarafından hazırlanan Aralık 2018 tarihli "MaSTER FRAME® Kullanarak Tipik Okul Binası Güçlendirme Raporu'nun hazırlanmasında kullanılan yöntemlerin güncel yönetmeliklere uygunluğunun incelenmesi istenmiştir. Söz konusu rapor PROMER Müş. Müh. A.Ş. ile birlikte Çevre ve Şehircilik Bakanlığı ve Garanti Koza – Maeda Corporation temsilcilerinin oluşturduğu bir Çalışma Grubu tarafından hazırlanmıştır. Bu teknik raporda ise, söz konusu raporun güncel yöntem ve şartnamelere uygunluğu ve rapor sonuçlarına bağlı olarak, tipik okul binalarının deprem dayanımlarının arttırılması ve güçlendirilmesinde MaSTER FRAME® yönteminin kullanılabilirliği ve etkinliği değerlendirilmiştir.

2. PROMER MÜŞ. MÜH. A.Ş. TARAFINDAN HAZIRLANAN "MaSTER FRAME© KULLANILARAK TİPİK OKUL BİNASI GÜÇLENDİRİLME RAPORU"

Çalışma kapsamında, MaSTER FRAME® (MF) güçlendirme yönteminin etkinliğini araştırmak üzere Türkiye'de yaygın olarak kullanılan okul tiplerinden *4 katlı betonarme çerçeve ve perde-çerçeve taşıyıcı sistem modeli ile 3 katlı betonarme çerçeve taşıyıcı sistem modeli olmak üzere 2 okul binası tipi* seçilmiştir. MF yöntemi ile güçlendirmede mevcut binalara dışarıdan betonarme çerçeveler eklenerek binaların deprem davranışının iyileştirilmesi hedeflenmektedir. MF güçlendirme çerçeveleri, binanın mevcut taşıyıcı elemanlarına bina dışından disk başlıklı özel ankrajlar kullanılarak takılmaktadır. MF yöntemiyle güçlendirilmesi hedeflenen binalar, *beton kalitesi en az 14MPa olan ve güçlendirme esnasında binanın içindeki kullanımın devam etmesi gereken binalar* olarak belirlenmiştir.

Çalışmada "*doğrusal elastik olmayan modelleme tekniği kullanılarak ve analiz yöntemi olarak Statik İtme analizi yöntemi kullanılarak ETABS v.16 yazılımı ile modelleme/analiz çalışmaları yapılmış ve DBYBHY-2007 Bölüm 7 kriterleri kullanılarak Mevcut Yapı Deprem Performans Analiz Raporunun hazırlanması*" işlerinin yapıldığı belirtilmiştir. Çalışmada ayrıca *güçlendirilmiş binanın performansı Zaman Tanım Alanında Analiz yöntemi kullanılarak yine DBYBHY-2007'ye göre* teyit edilmiştir.

Seçilen tipik 4 katlı betonarme perde-çerçeve sistem okul binasının 2000 yılı öncesi inşa edildiği kabul edilmiş olup, kat yükseklikleri 2.90m ve bir kat alanı 760m^{2}dir. Mevcut beton dayanımı 15.0 MPa, donatı sınıfı ise ST III (S420) olarak kullanılmıştır. I. Derece deprem bölgesindeki binanın zemin sınıfı Z3-C kabul edilmiştir. Temel tipi ise iki doğrultuda sürekli temeldir.

Seçilen 2. Bina örneği 3 katlı betonarme çerçeve taşıyıcı tipi bir okul binasını temsil etmekte olup 2000 yılı öncesi inşa edildiği kabul edilmiş, kat yükseklikleri 2.90m ve bir kat alanı 760m^2 olarak seçilmiştir. 4 katlı bina tipine benzer şekilde mevcut beton dayanımı 15.0 MPa, donatı sınıfı ise ST III (S420) olarak alınmıştır. I. Derece deprem bölgesindeki binanın zemin sınıfı Z3-C kabul edilmiştir. Temel tipi ise ki doğrultuda sürekli temeldir.

İncelenen çalışmada seçilen her iki bina tipi için de güçlendirme öncesi ve sonrası durumlarda binalar ayrı ayrı modellenmiş, deprem performans analizleri yapılmış, analiz sonuçlarının karşılaştırılmasıyla MF güçlendirme yönteminin etkinliği değerlendirilmiştir. Değerlendirmede, ilgili yönetmelikte elemanların kesit hasar sınırları, Minimum Hasar Sınırı (MN), Güvenlik Sınırı (GV) ve Göçme Sınırı (GÇ) olmaktadır. Buna bağlı olarak şekil değiştirme hasar bölgeleri;

Minimum Hasar Bölgesi, Belirgin Hasar Bölgesi, İleri Hasar Bölgesi ve Göçme Bölgesi olarak dikkate alınmaktadır.

Deprem yüklerinin hesabında bina önem katsayısı I=1.0 alınmıştır ve deprem kuvvetleri binaya her iki ortogonal yönde de uygulanmıştır.

Binaların deprem performansının değerlendirmesinde, ilgili yönetmelikte verildiği gibi, okul binalarında 50 yılda aşılma olasılığı %10 olan tasarım depremi seviyesi için Hemen Kullanım (HK), 50 yılda aşılma olasılığı %2 olan şiddetli (maksimum) deprem seviyesi için ise Can Güvenliği (CG) performans hedefleri dikkate alınmıştır.

DBYBHY 2007 7.6.9.2'de betonarme elemanlarda çeşitli kesit hasar sınırlarına göre izin verilen şekildeğiştirme üst sınırları aşağıdaki gibi verilmektedir:

a) Minimum Hasar Sınırı (MN):

$(\varepsilon_{cu})_{MN} = 0.0035$; $(\varepsilon_s)_{MN} = 0.010$

b) Kesit Güvenlik Sınırı (GV):

$(\varepsilon_{cu})_{GV} = 0.0035 + 0.01(\rho_s / \rho_{sm}) \leq 0.0135$; $(\varepsilon_s)_{GV} = 0.040$

c) Kesit Göçme Sınırı (GÇ)

$(\varepsilon_{cu})_{GC} = 0.004 + 0.014(\rho_s / \rho_{sm}) \leq 0.018$; $(\varepsilon_s)_{GC} = 0.060$

Çalışma kapsamında, öncelikle mevcut binaların deprem performansının belirlenmesi maksadıyla 50 yılda aşılma olasılığı %10 olan tasarım deprem seviyesinde (dönüş periyodu 475 sene olan deprem seviyesi) artımsal eşdeğer deprem yükü ile sabit modlu statik itme yöntemi kullanılmıştır. İtme analizlerinde öncelikle binaların kat kütleleri ilgili moddaki genlikleri ile çarpılarak ilk etapta yaklaşık %4 öteleme değerine kadar itme analizi yapılmış ve yönetmelikteki hesap yöntemine uygun olacak şekilde ilgili deprem seviyesine göre her iki ortogonal doğrultu için ayrı ayrı hedef deplasmanlar hesaplanmıştır.

Çalışmada kullanılan her 2 bina tipinin de yönetmelikte bu deprem seviyesi için öngörülen hemen kullanım performans seviyesini sağlamadığı tespit edildiği için, 50 yılda aşılma olasılığı %2 olan şiddetli deprem seviyesinde (dönüş periyodu 2475 sene olan deprem seviyesi) analiz gerekli görülmemiş, binaların güçlendirilmesi gerektiği sonucu belirtilmiştir. Mevcut binanın performans değerlendirmesinden sonra güçlendirme tasarımı ve güçlendirilmiş bina taşıyıcı sisteminin performansı için gerekli analizler yapılmıştır. MF yöntemi ile güçlendirilmiş bina modellerinde yönetmeliğe göre belirlenmiş her iki deprem seviyesi için belirtilen hedef performansların sağlandığı, doğrusal olmayan sabit modlu itme yöntemi kullanılarak büyük oranda tespit edilmiştir.

Raporun son aşamasında her iki bina tipi için de 50 yılda aşılma olasılığı %10 olan tasarım deprem seviyesinde "zaman tanım alanında doğrusal olmayan analiz" yöntemi kullanılarak binaların performansı teyit edilmiştir. Zaman tanım alanında analiz yönteminde Bolu, Düzce, Erzincan, Hector, Kobe, Kocaeli ve Lander Depremlerinin kayıtları yönetmeliğe uygun şekilde ölçeklendirilerek kullanılmıştır.

Yapılan analizler Tablo 1'de özetlenmektedir.

Tablo 1. İncelenen rapor kapsamında yapılan analizler

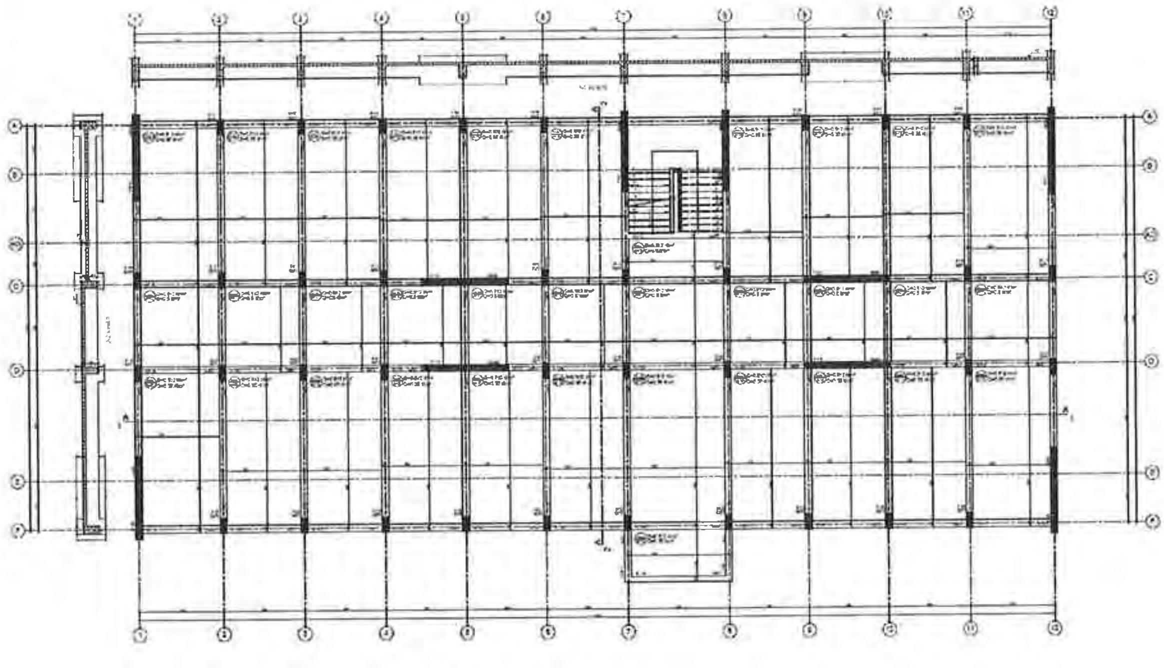
	4 Katlı Betonarme Perde-Çerçeve Sistem Bina	**3 Katlı Betonarme Çerçeve Sistem Bina**
Mevcut binanın değerlendirilmesi	Doğrusal Olmayan Sabit Modlu İtme Analizi (50 yılda aşılma olasılığı %10 seviyesi deprem durumu için)	Doğrusal Olmayan Sabit Modlu İtme Analizi (50 yılda aşılma olasılığı %10 seviyesi deprem durumu için)
MF ile güçlendirilmiş durumun değerlendirilmesi	- Doğrusal Olmayan Sabit Modlu İtme Analizi (50 yılda aşılma olasılığı %10 ve %2 olan deprem durumu için) - Zaman Tanım Alanında Dinamik Analiz (50 yılda aşılma olasılığı %10 seviyesi deprem durumu için)	- Doğrusal Olmayan Sabit Modlu İtme Analizi (50 yılda aşılma olasılığı %10 ve %2 olan deprem durumu için) - Zaman Tanım Alanında Dinamik Analiz (50 yılda aşılma olasılığı %10 seviyesi deprem durumu için)

2.1. 4 Katlı Betonarme Perde-Çerçeve Sistem Bina

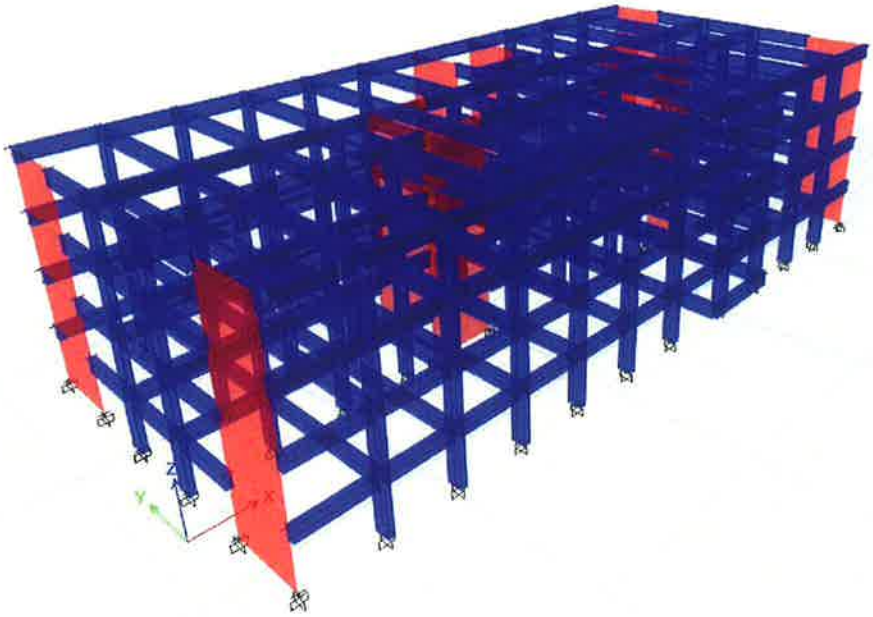
2.1.1. Mevcut 4 Katlı Perde-Çerçeve Sistem Binanın Deprem Performansının Değerlendirilmesi

Rapora konu olan 4 katlı betonarme perde-çerçeve sistem binanın tipik kat planı Şekil'1 de verilmiştir. Binanın tüm katlarında, betonarme çerçevelerine ek olarak planda uzun doğrultuda (x) 4 adet ve kısa doğrultuda (y) 6 adet betonarme perde bulunmaktadır. Kolon enkesit ölçüleri 30cm×70cm, kiriş enkesit ölçüleri 30cm×70cm ve perde enkesit ölçüleri 30cm×380cm'dır. Mevcut bina modelinde beton için 15.00 MPa beton basınç dayanımı ve donatı için STIII (S420) donatı sınıfı seçildiği anlaşılmaktadır. Kolon donatılarının 12ϕ14 olduğu, kirişlerde ise kesitte simetrik 3ϕ16 (kiriş alt ve üst yüzünde) donatı olduğu gösterilmiştir. Perdelerde ise toplam 2x21ϕ14 (her bir uç bölgesinde 10ϕ14) boyuna donatı kullanıldığı görülmektedir. Bina Deprem Yönetmeliği 2007'ye göre 1. Derece deprem bölgesinde bulunmaktadır ve zemin sınıfı olarak Z3 seçilmiştir. Etkin kesit rijitliklerinin tespiti için, daha önce Japonya'da yapılmış MF çerçeve deneyleri sayısal olarak modellenmiş ve analiz sonuçları deney sonuçlarına göre kalibre edilerek elde edilmiştir (Raporda Tablo 3.8). Mevcut binanın analizlerde kullanılan taşıyıcı sistem modeli Şekil 2'de gösterilmektedir.Modal analiz sonucunda binanın x ve y doğrultusundaki doğal titreşim periyotları sırasıyla 0.319s ve 0.282s olarak elde edilmiştir.

Mevcut 4 katlı binada yapılacak doğrusal olmayan sabit modlu itme analizi için hedef deplasmanlar, x doğrultusunda 0.055m, y doğrultusunda 0.044m olarak hesaplanmıştır.



Şekil 1. Mevcut 4 katlı perde-çerçeve sistem binanın tipik kat kalıp planı



Şekil 2. Mevcut 4 katlı perde-çerçeve sistem binanın üç boyutlu ETABS modeli

Promer Mühendislik tarafından hazırlanan hesap raporunda, kolon ve perdeler için eksenel kuvvet-toplam eğriliğe bağlı hasar sınırı grafikleri hazırlanmış, her bir eleman için elde edilen ilgili değerler aynı grafik üzerinde işaretlenerek hasar seviyeleri için ilgili sınırların içerisinde kalan eleman sayıları/oranları belirlenmiştir.

Mevcut 4 katlı betonarme perde-çerçeve sistem binada yapılan performans değerlendirmesi sonucu planda uzun doğrultu olan x doğrultusunda kolonların "Minimum Hasar" ve "Belirgin Hasar" bölgelerinde olduğu belirlenmiştir. y kısa doğrultusunda ise tüm kolonların minimum hasar bölgesinde olduğu belirlenmiştir. Perdelerde ise, x doğrultusunda zemin katta tüm perdelerin "Belirgin Hasar" bölgesinde olduğu diğer tüm katlarda perdelerin "Minimum Hasar" bölgesinde olduğu tespit edilmiştir. y doğrultusunda da benzer sonuçlar elde edilmekle birlikte, zemin kattaki perdeler Minimum Hasar bölgesi sınırına oldukça yakındır. Kirişlerde ise her iki doğrultuda belirgin hasar bölgesinde ve x doğrultusunda ileri hasar bölgesinde kirişler bulunduğu tespit edilmiştir. Bu bina modeli için kolon, perde ve kirişlerin performans değerlendirme özeti Tablo 2'de verilmektedir (Raporda Tablo 3.7).

Analizler ve performans değerlendirmesi sonucunda mevcut binanın 50 yılda aşılma olasılığı %10 olan tasarım depremi seviyesinde Deprem Yönetmeliği 2007'de belirtilen Hemen Kullanım performans seviyesini sağlamadığı ve güçlendirilmesi gerektiği tespit edilmiştir. Bu durumda 50 yılda aşılma olasılığı %2 olan şiddetli deprem seviyesi için analiz ve değerlendirme yapılmasına gerek görülmediği anlaşılmaktadır.

Tablo 2. 4-katlı perde-çerçeve taşıyıcı sistem modelinde mevcut durum performans değerlendirmesi özeti

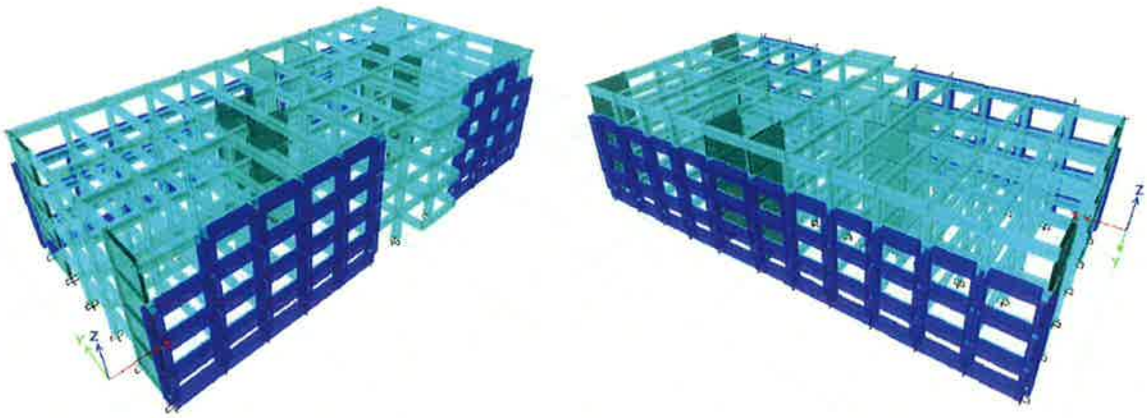
Tablo 3.7 Mevcut 4 Katlı Perdeli Yapı sabit modlu itme analizi performans değerlendirme özeti

MEVCUT 4 KATLI PERDELİ MODEL / PUSH X	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	32/36	4/36	--	36/44	6/44	2/44	4/4	--	--
2.KAT	33/36	3/36	--	36/44	6/44	2/44	4/4	--	--
1.KAT	34/36	2/36	--	36/44	6/44	2/44	4/4	--	--
ZEMİN KAT	34/36	2/36	--	36/44	6/44	2/44	--	4/4	--

MEVCUT 4 KATLI PERDELİ MODEL / PUSH Y	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36/36	--	--	32/38	6/38	--	6/6	--	--
2.KAT	36/36	--	--	29/38	8/38	--	6/6	--	--
1.KAT	36/36	--	--	30/38	8/38	--	6/6	--	--
ZEMİN KAT	36/36	--	--	32/38	6/38	--	--	6/6	--

2.1.2. MF ile Güçlendirilmiş 4 Katlı Perde-Çerçeve Sistem Binanın Performans Değerlendirmesi

Mevcut 4 katlı betonarme perde-çerçeve sistem bina, MaSTER FRAME® (MF) yöntemi kullanılarak güçlendirilmiş ve güçlendirilmiş durumdaki taşıyıcı sistemin yapısal deprem performansı değerlendirilmiştir. MF güçlendirme çerçevesi mevcut yapıya Disk-Ankraj olarak isimlendirilen özel ankrajlarla binanın uzun doğrultusuna paralel olarak dıştan bağlanmaktadır. MF güçlendirme çerçevesinin beton sınıfı C30, donatı sınıfı ise ST III (S420) olarak kullanılmıştır. Tüm MF kolon ve kiriş boyutları 65cm/80cm'dir. MF elemanlarının boyutları ve mevcut binanın uzun cephesinde toplam kaç katta ve hangi eksenlerde kullanılacağına karar verirken, öncelikle mümkün olan en az sayıda MF elemanı ile analizler yapılmasına başlanılmış ve güçlendirilmiş sistemde istenilen yapısal performans elde edilinceye kadar hem MF elemanlarının enkesit ölçüleri hem de kullanılan eleman sayısı kademeli olarak arttırılarak güvenli olan en ekonomik çözüm araştırılmıştır. Sonuç olarak tespit edilen MF güçlendirme konfigürasyonunun ETABS modeli Şekil 3'te gösterilmektedir.



Şekil 3. MF ile güçlendirilmiş 4 katlı perde-çerçeve sistem binanın üç boyutlu ETABS taşıyıcı sistem modeli

Modal analiz sonucunda MF ile güçlendirilmiş durumda binanın x ve y doğrultusundaki doğal titreşim periyotları sırasıyla 0.283s ve 0.271s olarak elde edilmiştir. Güçlendirme öncesi mevcut duruma ve güçlendirme sonrasındaki duruma ait tespit edilen titreşim periyodu değerleri aşağıdaki tabloda özetlenmiştir (Tablo 3). Güçlendirme sonrası, özellikle MF çerçevelerinin eklendiği planda (x) uzun doğrultuda, doğal titreşim periyodunda gözlemlenen azalma, yanal rijitlikteki artışa işaret etmesi bakımından beklenen bir değişim olarak değerlendirilmiştir.

Tablo 3. 4 Katlı perdeli bina modelinde güçlendirme öncesi ve sonrası doğal titreşim periyotları (s)

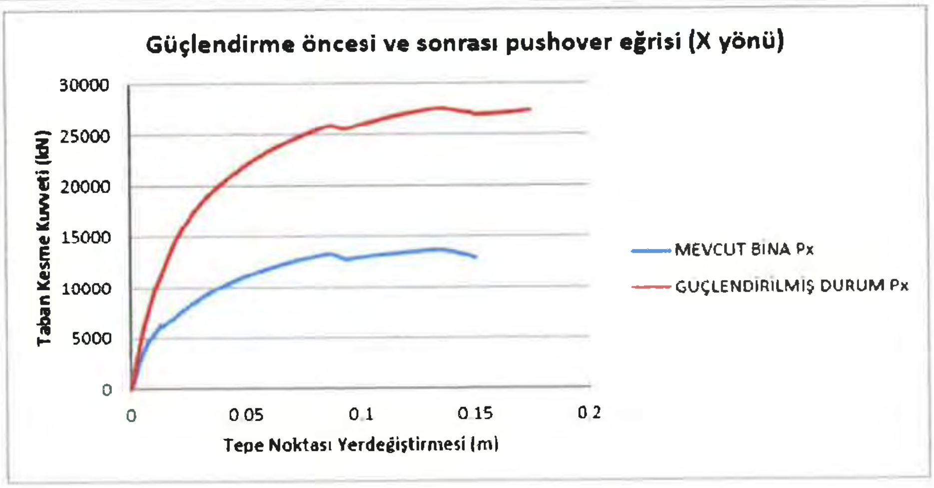
	4 Katlı Perdeli-Çerçeve Tipi Bina doğal titreşim periyodu	
	x (planda uzun doğrultu)	y (planda kısa doğrultu)
Mevcut bina	0.319	0.282
MF ile güçlendirilmiş bina	0.283	0.271

MF ile güçlendirilmiş durumda binada yapılacak doğrusal olmayan sabit modlu itme analizi için hedef deplasmanlar öncelikle 50 yılda aşılma olasılığı %10 olan tasarım depremi seviyesinde x doğrultusunda 0.036m, y doğrultusunda 0.050m olarak hesaplanmıştır. 50 yılda aşılma olasılığı %2 olan şiddetli deprem seviyesi için ise hedef deplasmanlar x doğrultusunda 0.064m, y doğrultusunda 0.079m olarak hesaplanmıştır. Güçlendirme öncesi ve sonrası durumlar için hesaplanan hedef deplasmanlar Tablo 4'te özetlenmiştir.

Tablo 4. 4 Katlı perdeli bina modelinde güçlendirme öncesi ve sonrası hedef deplasmanlar

	4 Katlı Perdeli-Çerçeve Tipi Bina için hedef deplasmanlar			
	50 yılda aşılma olasılığı %10		50 yılda aşılma olasılığı %2	
	X	Y	X	Y
Mevcut bina	0.055 m	0.044 m	-	-
MF ile güçlendirilmiş bina	0.036 m	0.050 m	0.064 m	0.079 m

MF ile güçlendirilmiş 4 katlı betonarme perde-çerçeve sistem binada yapılan itme analizi sonucu elde edilen kapasite (pushover) eğrisi ile mevcut güçlendirilmemiş binanın itme analizi sonucu elde edilen kapasite eğrileri Şekil 4'te gösterilmiştir (Raporda Şekil 3.16a). MF ile güçlendirme sonrası binanın MF çerçevesi eklenen x doğrultusunda rijitlik ve taban kesme kuvveti-çatı yerdeğiştirmesi seviyesinin önemli ölçüde arttığı görülmektedir.



Şekil 3.16a Güçlendirme öncesi ve sonrası itme eğrisi (X yönü)

Şekil 4. Güçlendirme öncesi ve MF ile güçlendirme sonrasında itme analizi kıyaslaması (4 katlı perdeli model - X yönü)

MF güçlendirmesi sonrası performans değerlendirmesi sonucu **tüm kolon ve perdelerin;** 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için, eksenel kuvvet-toplam eğrilik grafiğine işaretlenen performans-hasar sınırları dikkate alındığında, x ve y doğrultusunda MF kolonları da dahil olmak üzere, tüm düşey taşıyıcı elemanların minimum hasar bölgesinde kaldığı belirlenmiştir. Kirişlerde ise son derece sınırlı sayıda kirişin belirgin hasar bölgesinde olduğu tespit edilmiştir. "MF kirişleri de dahil edilerek" tüm kirişlerin deprem performansı değerlendirildiğinde belirgin hasar bölgesine geçen kirişlerin toplam kirişlere oranının 10% sınırının altında kaldığı tespit edilmiştir. Bu durumda MF ile güçlendirilen binanın 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için x doğrultusunda hemen kullanım performans seviyesini sağladığı tespit edilmiştir. Binanın y doğrultusunda ise yönetmelikte belirtilen 10% sınırının küçük bir farkla sağlanmadığı görülmektedir (4/38). Binanın y doğrultusunda MF kolonlarının değerlendirmesi yapılmamıştır.

MF ile güçlendirilen binanın 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için x ve y doğrultularındaki performans değerlendirme özet tablosu mevcut bina yapısal elemanları ve MF elemanları için ayrı ayrı Tablo 5'te verilmiştir (Raporda Tablo 3.13)

Tablo 5. 4-katlı perde-çerçeve sistem modelin MF ile güçlendirilmiş durumda performans değerlendirmesi özeti

Tablo 3.13 4 Katlı MaSTER FRAME® Uygulanmış Perdeli Yapı Sabit Modlu İtme Analizi Performans Değerlendirme Özeti

MaSTER FRAME® İLE GÜÇLENDİRİLMİŞ 4 KATLI PERDELİ MODEL / PUSH X									
	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36/36	--	--	34/44	4/44	--	4/4	-	--
2.KAT	36/36	--	--	34/44	4/44	--	4/4	-	--
1.KAT	36/36	--	--	34/44	4/44	--	4/4	-	--
ZEMİN KAT	36/36	--	--	34/44	4/44	--	4/4	-	--

MaSTER FRAME® İLE GÜÇLENDİRİLMİŞ 4 KATLI PERDELİ MODEL / PUSH Y									
	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36/36	--	--	36/38	2/38	--	6/6	--	--
2.KAT	36/36	--	--	34/38	4/38	--	6/6	--	--
1.KAT	36/36	--	--	34/38	4/38	--	6/6	--	--
ZEMİN KAT	36/36	--	--	34/38	4/38	--	6/6	--	--

Tablo 3.13b 4 Katlı MaSTER FRAME® Uygulanmış Perdeli Yapı Sabit Modlu İtme Analizi MaSTER FRAME® Elemanları Performans Değerlendirme Özeti

MASTER FRAME® İLE GÜÇLENDİRİLMİŞ 4 KATLI PERDELİ MODEL MaSTER FRAME'E AİT ELEMANLAR / PUSH X									
	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	8/8			6/6					
2.KAT	22/22	--	--	19/19	--	--	--	--	--
1.KAT	22/22	--	--	19/19	--	--	--	--	--
ZEMİN KAT	22/22	--	--	19/19	--	--	--	--	--

50 yılda aşılma olasılığı %2 olan şiddetli deprem seviyesinde ise, yapısal elemanlar için özet tablo bulunmamakta, bunun yerine düşey taşıyıcı elemanlar olan kolonlar ve perdeler için analizle elde edilen eğrilik değerleri öncekine benzer şekilde eksenel kuvvet – toplam eğrilik ile belirlenen hasar sınırları grafiği üzerinde gösterilmiştir.(İlgili raporda Şekil 3.18-c, 3.18-d, 3.20-a ve 3.20-b).

Raporda bu deprem şiddeti seviyesi için minimum hasar bölgesinin dışındaki düşey taşıyıcı elemanların adetleri veya taşıdıkları kesme kuvveti hakkında açık bilgi verilmemiş olmakla birlikte, şekillerde bu tür elemanların sayısının az olduğu görülmektedir. Bu analizlerde kirişlerin incelenmediği raporda belirtilmiştir. Rapordaki bilgiler ışığında şiddetli deprem seviyesi için düşey taşıyıcı elemanların performansının iyileştiği anlaşılmakla birlikte, Can Güvenliği performans seviyesinin sağlandığını söylemek için gerekli olan tüm bilgiler bulunmamaktadır.

MF ile güçlendirilmiş 4 katlı binanın **zaman tanım alanında analiz yöntemi** ile yapılan performans değerlendirmesi sonucunda da x ve y doğrultusunda tüm kolon ve perdelerin minimum hasar bölgesinde kaldığı gösterilmiştir. Kirişlerde ise, bazı kirişlerin belirgin hasar bölgesinde kaldığı ve tasarım depremi etkisinde beklenen performans seviyesi olan Hemen Kullanım seviyesinin gereği olan 10% sınırının bir miktar aşıldığı görülmektedir. (Tablo 6) Raporda bu durumun bina taşıyıcı sisteminin davranışına olumsuz etki yapacak düzeyde olmadığı gerekçesiyle gözardı edildiği belirtilmiştir.

Tablo 6. 4-katlı perdeli model MF ile güçlendirilmiş durum "zaman tanım alanında analiz" özeti

Tablo 3.14 4 Katlı MaSTER FRAME© Uygulanmış Perdeli Yapı sabit modlu itme analizi performans değerlendirme özeti

MaSTER FRAME© İLE GÜÇLENDİRİLMİŞ 4 KATLI PERDELİ MODEL / Time History	KOLON			KİRİŞ			PERDE		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
3.KAT	36/36	--	--	68/82	14/82	--	10/10	-	--
2.KAT	36/36	--	--	67/82	15/82	--	10/10	-	--
1.KAT	36/36	--	--	67/82	15/82	--	10/10	-	--
ZEMİN KAT	36/36	--	--	68/82	14/82	--	10/10	-	--

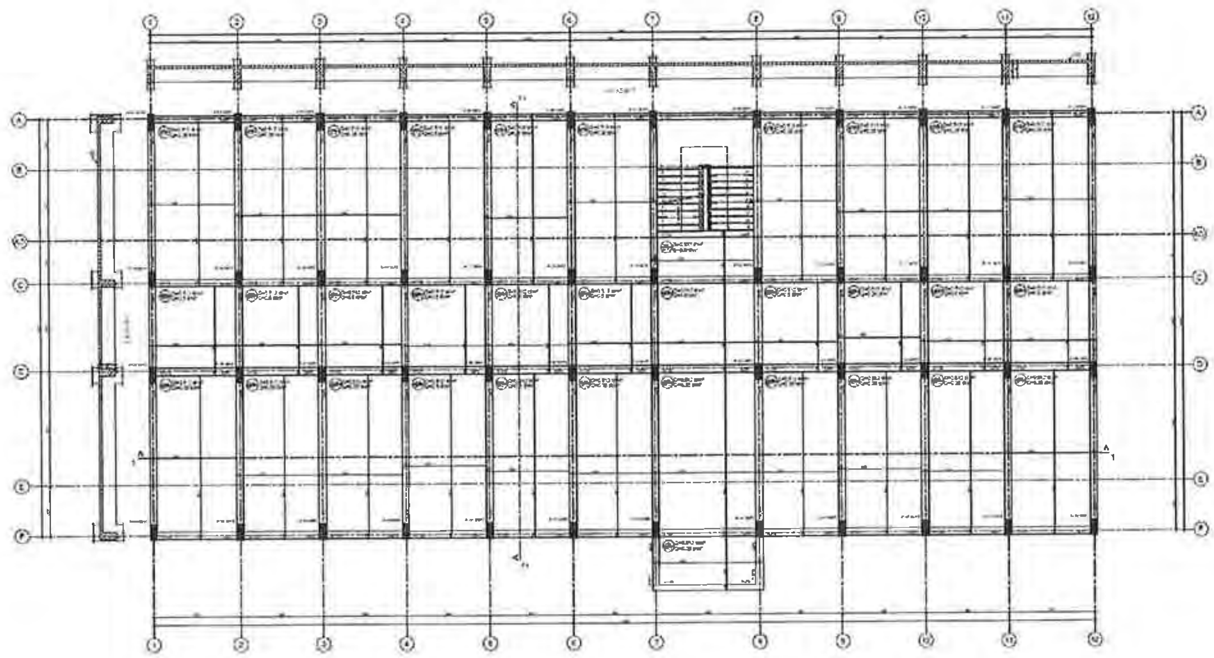
2.2. 3 Katlı Betonarme Çerçeve Sistem Bina

2.2.1. Mevcut 3 Katlı Betonarme Çerçeve Sistem Binanın Performans Değerlendirmesi

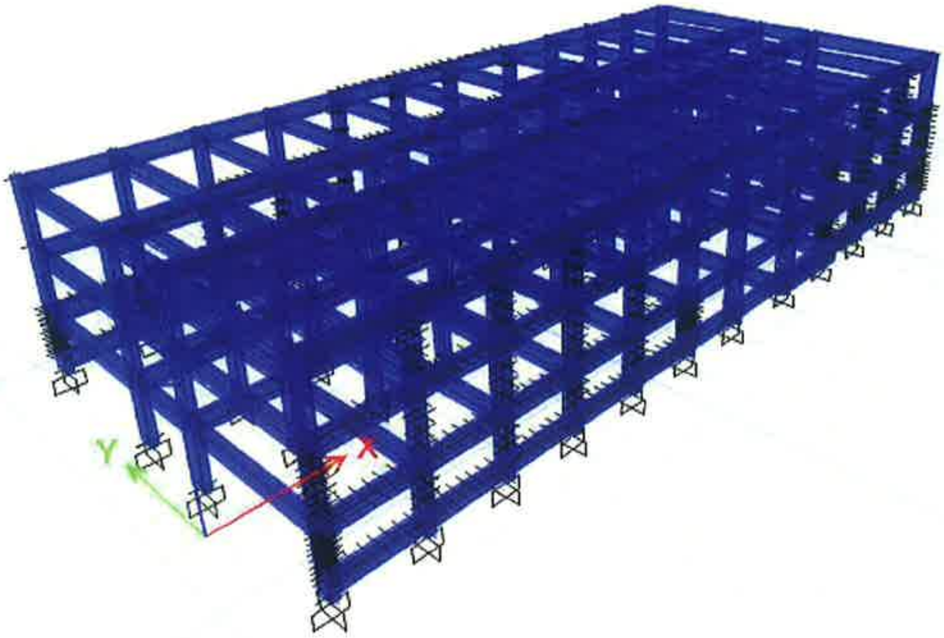
Binanın tipik kat planı Şekil 5'de verilmiştir. Tüm bina betonarme çerçeve taşıyıcı sistemle oluşturulmuştur. Kolon boyutları 30cm×70cm, kiriş boyutları ise 30cm/70cm'dir. Mevcut bina modelinde beton için 15.0 MPa beton basınç dayanımı ve donatı için STIII (S420) donatısı seçildiği anlaşılmaktadır. Kolon donatılarının 12ϕ14 olduğu, kirişlerde ise kesitte simetrik alt ve üst yüzde 3ϕ16 donatı olduğu belirtilmiştir. Bina Deprem Yönetmeliği 2007'ye göre 1. Derece deprem bölgesinde bulunmaktadır ve zemin sınıfı olarak Z3 seçilmiştir. Etkin kesit rijitliklerinin tespiti için, daha önce Japonya'da yapılmış MF çerçeve deneyleri sayısal olarak modellenmiş ve analiz sonuçları deney sonuçlarına göre kalibre edilerek elde edilmiştir (Raporda Tablo 3.14). Mevcut 3 katlı binanın analiz modeli Şekil 6'da verilmektedir.

Modal analiz sonucunda binanın x ve y doğrultusundaki doğal titreşim periyotları sırasıyla 0.621s ve 0.528s olarak elde edilmiştir.

Mevcut 3 katlı çerçeve sistem binada yapılacak doğrusal olmayan sabit modlu itme analizi için hedef deplasmanlar, x doğrultusunda 0.12m, y doğrultusunda 0.09m olarak hesaplanmıştır.



Şekil 5 Mevcut 3 katlı çerçeve sistem binanın kat kalıp planı



Şekil 6 Mevcut 3 katlı çerçeve sistem binanın üç boyutlu ETABS modeli

Raporda, kolonlar için eksenel kuvvet-toplam eğriliğe bağlı hasar sınırı grafikleri hazırlanmış, her bir eleman için elde edilen ilgili değerler aynı grafik üzerinde işaretlenerek hasar seviyeleri için ilgili sınırların içerisinde kalan eleman sayıları/oranları belirlenmiştir.

Mevcut 3 Katlı Betonarme Çerçeve sistem Binada yapılan performans değerlendirmesi sonucu planda uzun doğrultu olan x doğrultusunda kolonlardan "İleri Hasar Bölgesi" ve "Göçme Bölgesi"ndeelemanlar olduğu belirlenmiştir. Binanın y doğrultusunda ise tüm kolonların minimum hasar bölgesinde olduğu belirlenmiştir. Kirişlerde ise, x ve y doğrultularında belirgin ve ileri hasar bölgelerinde elemanlar bulunduğu belirtilmektedir. Kolon ve kirişler için performans değerlendirme sonuçları Tablo 7'de verilmektedir (Raporda Tablo 3.19).

Analizler ve performans değerlendirmesi sonucunda mevcut binanın 50 yılda aşılma olasılığı %10 olan tasarım depremi etkisinde binanın x doğrultusunda _yönetmelikte belirtilen Hemen Kullanım perfomans seviyesini sağlamadığı ve güçlendirilmesi gerektiği tespit edilmiştir. y doğrultusunda ise kirişlerde, yönetmelikte izin verilen sınırdan daha fazla kirişte belirgin/ileri hasar oluşmasına rağmen (Tablo 7.3), adedin fazla olmadığı ve yapısal davranışa etkisinin görece az olacağı gerekçesiyle bu durum ihmal edilerek bu doğrultuda güçlendirme gerekmediği belirtilmiştir. x doğrultusunda kullanılacak güçlendirme çerçevelerinin y doğrultusunda da yapısal davranışa olumlu etkisi olacağı düşünülmektedir. Bu durumda 50 yılda aşılma olasılığı %2 olan şiddetli deprem için analiz ve değerlendirme yapılmasına gerek görülmemiş ve binanın güçlendirilmesi aşamasına geçilmiştir.

Tablo 7. 3 katlı betonarme çerçeve sistem binanın mevcut durum performans değerlendirmesi özeti

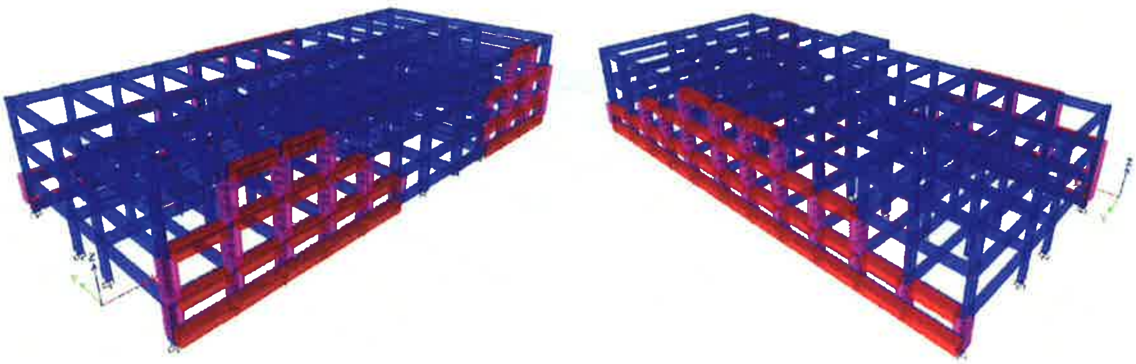
Tablo 3.19 3 Katlı Mevcut Perdesiz Yapı Sabit Modlu İtme Analizi Performans Değerlendirme - Özeti X ve Y Yönü

3 KATLI MEVCUT MODEL / PUSH X							
	KOLON				KİRİŞ		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	GÖÇME	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
2.KAT	48/48	--	--	--	44/44	--	--
1.KAT	25/48	2/48	6/48	15/48	35/44	9/44	--
ZEMİN KAT	33/48	15/48	--	--	36/44	7/44	1/44

3 KATLI MEVCUT MODEL / PUSH Y							
	KOLON				KİRİŞ		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	GÖÇME	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
2.KAT	48/48	--	--	--	44/44	0/44	--
1.KAT	48/48	--	--	--	32/44	12/44	--
ZEMİN KAT	48/48	--	--	--	27/44	10/44	7/44

2.2.2. MF'li 3 Katlı Betonarme Çerçeve Sistem Bina Performans Değerlendirmesi

Mevcut 3 katlı betonarme çerçeve sistem bina, MaSTER FRAME® yöntemi kullanılarak güçlendirilmiş ve güçlendirilmiş durumdaki taşıyıcı sistemin deprem performansı değerlendirilmiştir. MF güçlendirme çerçevesi mevcut binaya Disk-Ankraj olarak isimlendirilen özel ankrajlarla bina dışından ve binanın uzun doğrultusuna paralel olarak bağlanmaktadır. MF güçlendirme çerçevesinin beton sınıfı C30 (basınç dayanımı 30MPa), donatı sınıfı ise ST III (S420) olarak kullanılmıştır. Güçlendirme amacıyla kullanılan tüm MF çerçevelerinin kolon ve kiriş boyutları 65cm×80cm'dir. MF elemanlarının boyutları ve mevcut binanın uzun cephesinde toplam kaç katta ve hangi eksenlerde kullanılacağına karar verilirken, öncelikle mümkün olan en az sayıda MF elemanı ile analizler yapılmaya başlanmış ve istenilen yapısal performans elde edilinceye kadar hem MF elemanlarının enkesit ölçüleri hem de kullanılan eleman sayısı kademeli olarak arttırılarak güvenli olan en ekonomik çözüm araştırılmıştır. Sonuç olarak tespit edilen MF güçlendirme konfigürasyonunun ETABS modeli Şekil 7'te gösterilmektedir.



Şekil 7. MF'li 3 katlı çerçeve sistem binanın üç boyutlu ETABS modeli

Modal analiz sonucunda MF ile güçlendirilmiş durumda binanın x ve y doğrultusundaki doğal titreşim periyotları sırasıyla 0.331s ve 0.524s olarak elde edilmiştir. Güçlendirme öncesi mevcut duruma ve güçlendirme sonrasındaki duruma ilişkin olarak tespit edilen titreşim periyodu değerleri aşağıdaki tabloda özetlenmiştir (Tablo 8). Güçlendirme sonrası, özelikle MF çerçevelerinin eklendiği planda (x) uzun doğrultuda, doğal titreşim periyodunda görülen azalma yapısal rijitlikteki artışa işaret etmesi bakımından beklenen bir değişim olarak değerlendirilmiştir.

Tablo 8. 3 Katlı çerçeve tipi bina modelinde güçlendirme öncesi ve sonrası doğal titreşim periyotları

	3 Katlı Çerçeve Tipi Bina doğal titreşim periyodu	
	X (planda uzun doğrultu)	Y (planda kısa doğrultu)
Mevcut bina	0.621 s.	0.528s.
MF ile güçlendirilmiş bina	0.331 s.	0.524 s.

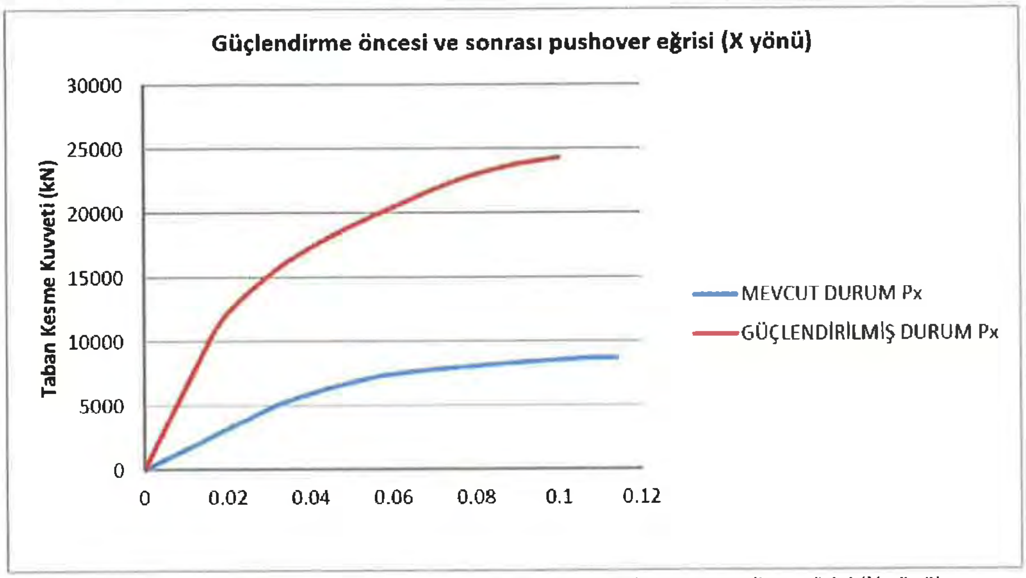
MF ile güçlendirilmiş durumda binada yapılacak doğrusal olmayan sabit modlu itme analizi için hedef deplasmanlar öncelikle 50 yılda aşılma olasılığı %10 olan tasarım depreminde x doğrultusunda 0.049m, y doğrultusunda 0.097m olarak hesaplanmıştır. 50 yılda aşılma olasılığı %2 olan şiddetli deprem için ise hedef deplasmanlar x doğrultusunda 0.082m, y doğrultusunda 0.155m olarak hesaplanmıştır. Güçlendirme öncesi ve sonrası durumlar için hesaplanan hedef deplasmanlar Tablo 9'da özetlenmiştir.

Tablo 9. 3 Katlı çerçeve tipi bina modelinde güçlendirme öncesi ve sonrası hedef deplasmanlar

	3 Katlı Çerçeve Tipi Bina hedef için deplasmanlar			
	50 yılda aşılma olasılığı %10		50 yılda aşılma olasılığı %2	
	X	Y	X	Y
Mevcut bina	0.12 m	0.09 m	-	-
MF ile güçlendirilmiş bina	0.049 m	0.097 m	0.082 m	0.155m

MF ile güçlendirilmiş 3 katlı betonarme çerçeve sistem binada yapılan itme analizi ile mevcut çerçeve sistem binanın itme analizi sonuçları karşılaştırmalı olarak Şekil 8'te gösterilmiştir (Raporda Şekil 3.36a). MF ile güçlendirme sonrası binanın MF çerçevesi eklenen x doğrultusunda, rijitlik ve taban kesme kuvvetinin önemli ölçüde arttığı görülmektedir.

Güçlendirme öncesi ve sonrası, itme ağrisi kıyaslaması:



Şekil 3.36a 3 Katlı Bina Güçlendirme öncesi ve sonrası itme ağrisi (X yönü)

Şekil 8. Güçlendirme öncesi ve MF ile güçlendirme sonrasında itme analizi kıyaslaması (3 katlı çerçeve model- x doğrultusu)

MF ile güçlendirme sonrası yapılan performans değerlendirmesinde **tüm kolonların;** 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için, eksenel kuvvet-toplam eğrilik grafiğine işaretlenen performans-hasar sınırları dikkate alındığında, x doğrultusunda MF kolonları da dahil olmak üzere tüm düşey taşıyıcı elemanların minimum hasar bölgesinde kaldığı belirlenmiştir.Binanın y doğrultusunda MF ile güçlendirilmiş sistem için performans analizi yapılmamıştır. Kirişlerde ise son derece sınırlı sayıda kirişin belirgin hasar bölgesinde olduğu tespit edilmiştir. "MF kirişleri de dahil edilerek" tüm kirişlerin performansı değerlendirildiğinde, belirgin hasar bölgesine geçen kirişlerin toplam kirişlere oranının 10% sınırının altında kaldığı tespit edilmiştir. Bu durumda MF ile güçlendirilen binanın 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için x doğrultusunda Hemen Kullanım performans seviyesini sağladığı tespit edilmiştir.

MF ile güçlendirilen binanın 50 yılda aşılma olasılığı %10 olan Tasarım Depremi seviyesi için x doğrultusundaki performans değerlendirme özet tablosu mevcut bina yapısal elemanları ve MF elemanları için ayrı ayrı Tablo 10'da verilmiştir (Raporda Tablo 3.25).

Tablo 10. 3 katlı çerçeve model MF ile güçlendirilmiş durum performans değerlendirmesi özeti

Tablo 3.25 3 Katlı MASTER FRAME® Uygulanmış Perdesiz Yapı Sabit Modlu İtme Analizi Tasarım Depremi Etkisi Altında Performans Değerlendirme - Özeti X Yönü

MASTER FRAME® İLE GÜÇLENDİRİLMİŞ 3 KATLI PERDESİZ MODEL / PUSH X									
	KOLON			KİRİŞ			--		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	--	--	--
2.KAT	48/48	--	--	44/44	--	--	--	--	--
1.KAT	48/48	--	--	44/44	--	--	--	--	--
ZEMİN KAT	48/48	--	--	40/44	4/44	--	--	--	--

MASTER FRAME® İLE GÜÇLENDİRİLMİŞ 3 KATLI PERDESİZ MODEL MaSTER FRAME'E AİT ELEMANLAR / PUSH X									
	KOLON			KİRİŞ			--		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	--	--	--
2.KAT	9/9	--	--	6/6	--	--	--	--	--
1.KAT	17/17	--	--	14/14	--	--	--	--	--
ZEMİN KAT	22/22	--	--	19/19	--	--	--	--	--

50 yılda aşılma olasılığı %2 olan şiddetli deprem seviyesinde ise, hesap raporunda yapısal elemanlar için özet tablo verilmemiş, bunun yerine düşey taşıyıcı elemanlar olan kolonlar için analizlerden elde edilen eğrilik değerleri öncekine benzer şekilde, eksenel kuvvet - toplam eğrilik ile belirlenen hasar sınırları grafiği üzerinde gösterilmiştir (İlgili raporda Şekil 3.37-c ve Şekil 3.37-d). Raporda bu şiddetli deprem için minimum hasar bölgesinin dışındaki düşey taşıyıcı elemanların adetleri veya taşıdıkları kesme kuvveti ve bu kuvvetin kat kesme kuvvetine oranı gibi konular hakkında açık bilgi verilmemiş olmakla birlikte, şekillerde bu tür elemanlarının sayısının az olduğu görülmektedir. Bu analizlerde kirişlerin incelenmediği, değerlendirme dışı tutulduğu hesap raporunda belirtilmiştir. Rapordaki bilgiler ışığında şiddetli deprem seviyesi için düşey taşıyıcı elemanların performansının iyileştiği anlaşılmakla birlikte, Can Güvenliği performans seviyesinin sağlandığını söylemek için gerekli olan tüm bilgiler raporda bulunmamaktadır.

MF ile güçlendirilmiş 3 katlı binanın **zaman tanım alanında analiz yöntemi** ile yapılan performans değerlendirmesi sonucunda da x ve y doğrultularında tüm kolonların minimum hasar bölgesinde kaldığı gösterilmiştir. Kirişlerde ise, bazı kirişlerin belirgin hasar bölgesinde kaldığı ve tasarım depreminde beklenen performans seviyesi olan Hemen Kullanım performans seviyesi gereği kiriş hasar oranının 10% sınırının üstünde (30% seviyesinde) olduğu görülmektedir. (Tablo

11, Raporda Tablo 3.26). Raporda kirişlerle ilgili bu durumun bina davranışına olumsuz etki yapacak düzeyde olmadığı gerekçesiyle gözardı edildiği belirtilmiştir.

Tablo 11. 3 katlı model MF ile güçlendirilmiş durum "zaman tanım alanında analiz" özeti

Tablo 3.26 3 Katlı Perdesiz MaSTER FRAME(C) ile Güçlendirilmiş Yapı Zaman Tanım Alanında Analiz Yöntemi İle Perfomans Analizi Özet Tablosu X ve Y yönü

MASTER FRAME® İLE GÜÇLENDİRİLMİŞ 3 KATLI PERDESİZ MODEL / Time History						
	KOLON			KİRİŞ		
	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR	MİN HASAR	BELİRGİN HASAR	İLERİ HASAR
2.KAT	4/48	--	--	80/82	2/82	--
1.KAT	48/48	--	--	59/82	23/82	--
ZEMİN KAT	48/48	--	--	54/82	28/82	--

3. DEĞERLENDİRME VE SONUÇ

Okul binaları genel olarak planda ve düşeyde düzgün taşıyıcı sisteme sahip olup, kapalı çıkma içermezler. Betonarme çerçeve taşıyıcı sistem yanında, genel olarak perde-çerçeve taşıyıcı sisteme sahiptirler. Ülkemizde yaşanan ve aletsel büyüklüğü 6.0~7.0 gibi olan ve tasarım depremi sayılabilecek depremlerde okul binalarında önemli yapısal hasarlar meydana geldiği gözlenmektedir. Bu durum mevcut okul binalarının incelenerek gerekli görülenlerin güçlendirilmesini zorunlu kılmaktadır. Alışılagelen türden taşıyıcı sistem güçlendirmesi yapılması durumunda (mevcut taşıyıcı sisteme perde ilavesi ve kolon mantolanması, temellerin bütünleştirilmesi gibi), okulda eğitime ara verilmesi gerektiği, ya da yetiştirilebilecekse, yaz aylarından güçlendirme yapılması mümkün olabilmektedir. Genellikle yaz tatil dönemi yeterli olmamakta, eğitime ara verilmesi ve öğrencilerin başka okullara taşınması gerekli olmaktadır.

Bu çalışma kapsamında öngörülen güçlendirme yöntemi (MaSTER FRAME®) ile yapılan güçlendirme, bina içine girilmeksizin gerçekleştirildiğinden, güçlendirme işleminin yaz tatili içinde tamamlanmasının mümkün olabileceği belirtilebilir. Güçlendirme maliyetinin, alışılagelen güçlendirme yöntemine göre daha ekonomik olacağı, iki yönteme (alışılagelen mevcut taşıyıcı sisteme perde ilavesi ve gerekli görülen kolonların mantolanması ve MaSTER FRAME® yöntemi) göre yapılacak güçlendirme çalışmalarında maliyet belirlenmesi ile tespit edilebilir. Bu türden sonuca ulaşılmasında, taşıyıcı olmayan duvar, döşeme kaplaması, fayans vb. kırılması ve nakliyesi ve yeniden döşeme kaplaması ve fayans döşenmesi, sıva ve boya yapılması ihtiyacının maliyet artışında rolü olacağı belirtilebilir.

Promer Müşavirlik Mühendislik A.Ş. tarafından aynı alana sahip betonarme bir okul binası ele alınmış, okul binasının 4 katlı (zemin kat + 3 normal kat) perde-çerçeve taşıyıcı sistem ve 3 katlı (zemin kat + iki normal kat) çerçeve taşıyıcı sistem olması durumunda deprem performansları Deprem Yönetmeliği 2007 doğrultusunda incelenmiş ve elde edilen sonuçlar ayrı ayrı verilmiştir. Okul binaları için Deprem Yönetmeliği 2007'de iki performans düzeyinin sağlanması öngörülmüştür. Buna göre, okul binası taşıyıcı sistemlerinin tasarım depremi etkisinde 'hemen kullanım', şiddetli (maksimum) deprem etkisinde ise 'can güvenliği' performans seviyesini sağlaması gereklidir.

Promer Müşavirlik Mühendislik A.Ş. tarafından ele alınan iki okul binası taşıyıcı sistemlerinin deprem performanslarının belirlenmesi için analizler gerçekleştirilmiştir. Tasarım depremi etkisinde hemen kullanım performans seviyesinin sağlanmaması gerekçesiyle, okul binaları taşıyıcı sistemlerinin güçlendirilmesine karar verilmiştir. Maksimum (şiddetli) deprem etkisinde caan güvenliği performans seviyesinin sağlanıp sağlanmadığının kontroluna ihtiyaç duyulmamıştır.

İki okul binasının da tasarım depremi etkisinde hemen kullanım performans seviyesini sağlamamaları sebebiyle, MF ile güçlendirilmiş taşıyıcı sistemler için performans analizleri yapılmıştır. Buna göre 4 katlı perde-çerçeve taşıyıcı sisteme sahip okul binasında bazı kirişlerin belirgin hasar bölgesinde olması sebebiyle, kiriş hasarlarının gözardı edilmesi durumunda tasarım depremi ve maksimum deprem etkisinde sırasıyla hemen kullanım ve can güvenliği performans seviyelerinin sağlandığı gösterilmiştir. 3 katlı çerçeve taşıyıcı sisteme sahip okul binasının MF ile güçlendirilmesi sonrasında yapılan performans analizlerinden, hemen kullanım ve can güvenliği performans seviyelerinin sağlandığı gösterilmiştir. Her iki okul binasında da MF ile güçlendirme, okul binalarının bir doğrultusundaki iki cephesinde uygulanmış, yapılan analizler sonucunda, MF uygulanmayan doğrultuların deprem performansında iyileştirme meydana geldiği belirtilmiştir.

Dünya Bankası kredi ile İPKB tarafından İSMEP projesi kapsamında İstanbul'da çok sayıda okul binası güçlendirilmiştir. Konuya ilişkin olarak Mart 2007'de (Deprem Yönetmeliği 2007 yürürlüğe girmeden önce) hazırlanan teknik şartnamede, okul güçlendirmelerinin mevcut taşıyıcı sisteme perde ilavesi ve kolon mantolanması şeklinde yapılması öngörülmüş, kiriş güçlendirilmesine yer verilmemiştir. Dolayısıyla, İstanbul'da bulunan çok sayıda okul binası bu doğrultuda güçlendirilmiştir. Rapora konu inceleme kapsamında, 4 katlı binada MF ile güçlendirme sonrasında bazı kiriş hasar oranlarının aşılması nedeniyle hemen kullanım performans düzeyinin sağlanmamasının, yukarıda belirtilen gerekçe ile, kayda değer bir olumsuzluk teşkil etmediği görüş ve kanaatindeyiz.

Yapılan analizlerde, okul binalarında bodrum kat bulunmadığı kabul edilmiş, temel sistemi hakkında bilgi verilmemiştir. MF'in okul binası mevcut taşıyıcı sistemine tespitinde, temel sistemi ve temellerde herhangi bir güçlendirme (temel bütünleştirmesi vb.) gerekli olup olmadığı belirtilmemiştir.

Yukarıda verilen tüm açıklama ve değerlendirmeler çerçevesinde, MF kullanılarak okul güçlendirmesi yapılmasının, gerek güçlendirme süresinin sınırlı (örneğin yaz tatilinde yapılabilecek) olması ve gerekse okul binası içine girilmediği için güçlendirme maliyetinin sınırlı kalmasının bir avantaj olabileceği değerlendirilmiştir. Okul binası kat adedine bağlı olarak, kiriş hasar oranlarının aşılabileceği, dolayısıyla tasarım depremi etkisinde hemen kullanım performans seviyesinin sağlanamamasının, geçmişte yapılan okul binası güçlendirmelerinde, kiriş hasarları gözardı edildiğinden, problem teşkil etmeyeceği düşünülmektedir. Ayrıca, Türkiye Bina Deprem Yönetmeliği 2018'de, Deprem Yönetmeliği 2007'de çok katı olan kiriş hasar oranları da arttırılmıştır.

Saygılarımızla,

Prof. Dr. Kadir GÜLER Dr. Öğr. Üyesi Fatih SÜTCÜ

İstanbul Teknik Üniversitesi, İnşaat Fakültesi, İnşaat Mühendisliği Bölümü

添付２　タスクフォース報告書
イスタンブール工科大学による検証報告（英語）

Asst. Prof. Fatih Sutcu
2019.03.12
Brief Technical Evaluation of Task Force Report

Promer Engineering has prepared a Task Force (TF) report regarding the MasterFrame (MF) retrofit of 2 example school buildings representing Turkish schools. First building model is a 4 story RC school building with shear walls and moment resisting frames. Second model is a 3 story school building with only moment resisting frames. The concrete grade is C15. **Comment:** The building models used for this study represents almost 15 % of sub-standart school buildings in Turkey.

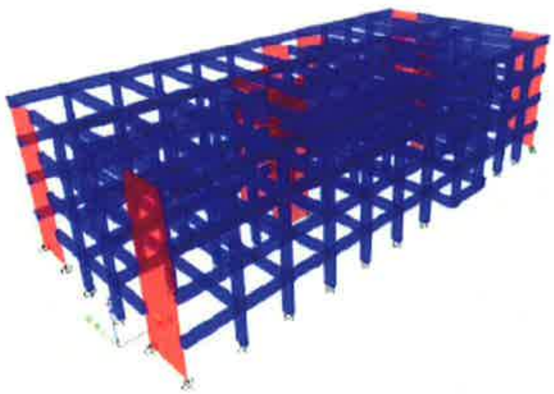


Figure 1.1 3D View 4 Storey Building with Shear Wall.

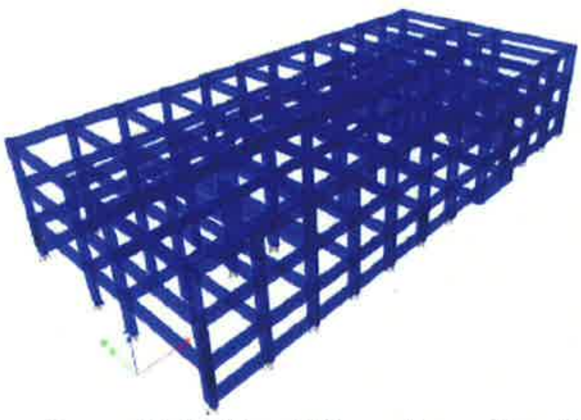


Figure 1.2 3D View 3 Storey Frame Type Building

The analysis for evaluation is made depending on the Turkish Seismic Code 2007. This code has recently been replaced by 2019 Code. Basically these codes are similar in essential topics. There are slight differences in determining the equivalent seismic load and performance evaluation.

According to the 2007 Code, School type buildings should be evaluated under 2 different seismic levels. 1st seismic level used in the study is the 2500year return period earthquake level which corresponds to the 2% exceedance probability in 50 years (Maximum Considered Earthquake: MCE). In this seismic level, the School buildings should satisfy a "Life Safety" structural performance level. (In each performance level structural members such as beams, columns and shear walls should be within certain damage levels determined according to member deformations)

2nd seismic level is the 500 year return period earthquake level which corresponds to the 2% exceedance probability in 50 years (Design Base Earthquake: DBE) in this seismic level, the School buildings should satisfy a "Immediate Occupancy " structural performance level.

Table 1.1 Summary of Typical 4 storey R/C building with Shear Wall

Building Name	:	**Typical 4 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Building Type	:	Reinforced Concrete with Shear Wall
Storey Height, Area, Number of Storey	:	2.9 m 760 m2 4 storey
Total Area	:	3040 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Participation Factor	:	0.60
Floor Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Floor Storey Loads	:	G=1.49 kN/m2, Q= 2.25 kN/m2
Wall Unit Weights	:	3.90 kN/m2
Foundation Type	:	Continuous Footing
Expected Performance	:	Immediate occupancy in the earthquake with 10 % exceedance probabilty in 50 years. And Life Safety in the earthquake with 2 % exceedance probabilty in 50 years
Used Cracked Section Factor	:	Column: I_{22}, I_{33} =0.4 Beam : I_{33} = 0.4

Tablo 1.2 Summary of Typical 3 storey R/C building without Shear Wall

Building Name	:	**Typical 3 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Building Type	:	Reinfonced Concrete Frame Type
Storey Height, Area, Number of Storey	:	2.9 m - 760 m2 - 3 Storey
Total Area	:	2280 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Participation Factor	:	0.60
Floor Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Floor Storey Loads	:	G=1.49 kN/m2, Q= 2.25 kN/m2
Wall Unit Weights	:	3.90 kN/m2
Foundation Type	:	Continious Footing
Expected Performance	:	Immediate occupancy in the earthquake with 10 % exceedance probabilty in 50 years. And Life Safety in the earthquake with 2 % exceedance probabilty in 50 years
Used Cracked Section Factor	:	Column: I_{22}, I_{33} =0.4 Beam : I_{33} = 0.4

According to the TF agreement, Promer Engineering is requested to do seismic evaluation of existing building models and also evaluate the performance of the buildings after retrofit and show that retrofit structure satisfies the 2007 Seismic Code requirements.

In the analysis Promer Engineering used nonlinear push over analysis for evaluating the existing building and also the retrofit building. Later, nonlinear time history analysis (THA) is used only at DBE seismic level for verification of results.

4 story RC building model with shear walls

In this model, the existing structure didn't satisfy the Code designated performance under DBE seismic level. As seen in Table 3.7 several columns and shear walls exceed the minimum damage level and some beams even reach advanced damage level. Therefore there is no need to use the MCE seismic level. Building is evaluated as "retrofit required".

Table 3.7 Summary table of performance evaluation with fixed first mode pushover analysis for existing 4 storey building with shear walls

EXISTING 4 STOREY BUILDING WITH SHEAR WALL / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	32/36	4/36	--	36/44	6/44	2/44	4/4	--	--
2nd storey	33/36	3/36	--	36/44	6/44	2/44	4/4	--	--
1st storey	34/36	2/36	--	36/44	6/44	2/44	4/4	---	--
Ground Floor	34/36	2/36	--	36/44	6/44	2/44	--	4/4	--

EXISTING 4 STOREY BUILDING WITH SHEAR WALL / PUSH Y									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	32/38	6/38	--	6/6	--	--
2nd storey	36/36	--	--	29/38	8/38	--	6/6	--	--
1st storey	36/36	--	--	30/38	8/38	--	6/6	--	--
Ground Floor	36/36	--	--	32/38	6/38	--	--	6/6	--

After MF retrofit the nonlinear pushover analysis is performed and the performance level of the buildings is evaluated according to the damage level of each structural member. The type of MF is shown on Figure 3.14.

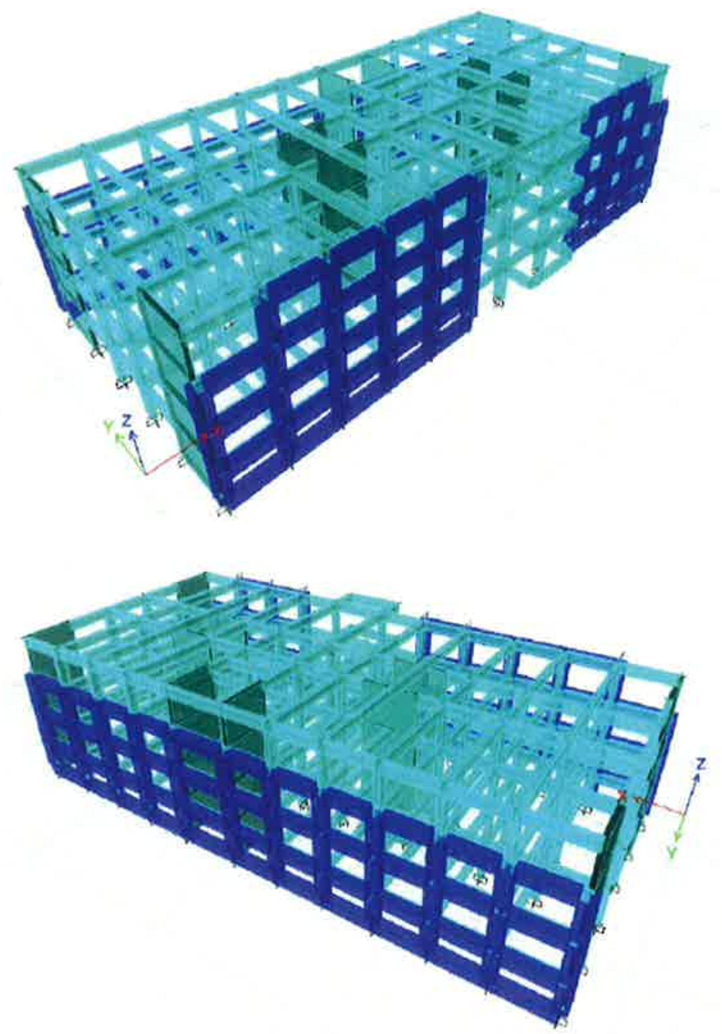


Figure 3.14 3D ETABS model of 4 storey structure and retrofitted using MaSTER FRAME®

In the DBE seismic level (500 years) after MF retrofit following table that shows damage levels of each structural member has been obtained. From table we can understand that most of the structural members are in the minimum damage zone after MF retrofit. Only some beams are in significant damage zone (written as "marked damage" in report) According to the 2007 Seismic code, 10% of beams are allowed in the significant damage zone. In this case the ratio is 10,5% in Y direction.

Tablo 3.13 Summary Table of Assesment with Fixed First Mode Pushover Analysis Under Design Earthquake effect for 4 storey building retrofitted using MaSTER FRAME®

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	40/44	4/44	--	4/4	-	--
2nd storey	36/36	--	--	40/44	4/44	--	4/4	-	--
1st storey	36/36	--	--	40/44	4/44	--	4/4	-	--
Ground Floor	36/36	--	--	40/44	4/44	--	4/4	-	--

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / PUSH Y									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	36/38	2/38	--	6/6	--	--
2nd storey	36/36	--	--	34/38	4/38	--	6/6	--	--
1st storey	36/36	--	--	34/38	4/38	--	6/6	--	--
Ground Floor	36/36	--	--	34/38	4/38	--	6/6	--	--

Tablo 3.13b Summary Table of Assesment with Fixed First Mode Pushover Analysis Under Design Earthquake effect for MaSTER FRAME® system members of 4 storey building retrofitted using MaSTER FRAME®

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME® (MaSTER FRAME's Members) / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	8/8			6/6					
2nd storey	22/22	--	--	19/19	--	--	--	--	--
1st storey	22/22	--	--	19/19	--	--	--	--	--
Ground Floor	22/22	--	--	19/19	--	--	--	--	--

<u>In the MCE seismic level </u>(2500 years) only column and shear wall damage levels are shown on graphs (these graphs are representing the axial load vs total end rotation of each member). Beam damage levels are not shown on graph or table form whatsoever. There is no summary table for vertical members either. From the given figures it seems most vertical structural members are within the "minimum damage zone" however the percentage of the members exceeding this

zone and also the ratio of total shear force value of members that are outside the minimum damage zone to the total story shear is not clear from these figures. Promer Engineering reports that Life Safety performance level is satisfied for vertical members and the beams are not investigated. Example graph is given in Figure 3.20a. It seems some shear walls exceeds the minimum damage level, however their contribution (ratio) to the story shear force is unknown. In the report Promer Engineering clearly states that vertical members satisfies the designated damage levels for the target performance level (in Promer's Report 3.2.4.3)

B) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 2 % IN 50 YEARS (MAXIMUM CONSIDERED EARTHQUAKE

In this section the retrofitted building is checked for the earthquake level with return period of 2500 years for life safety performance level.

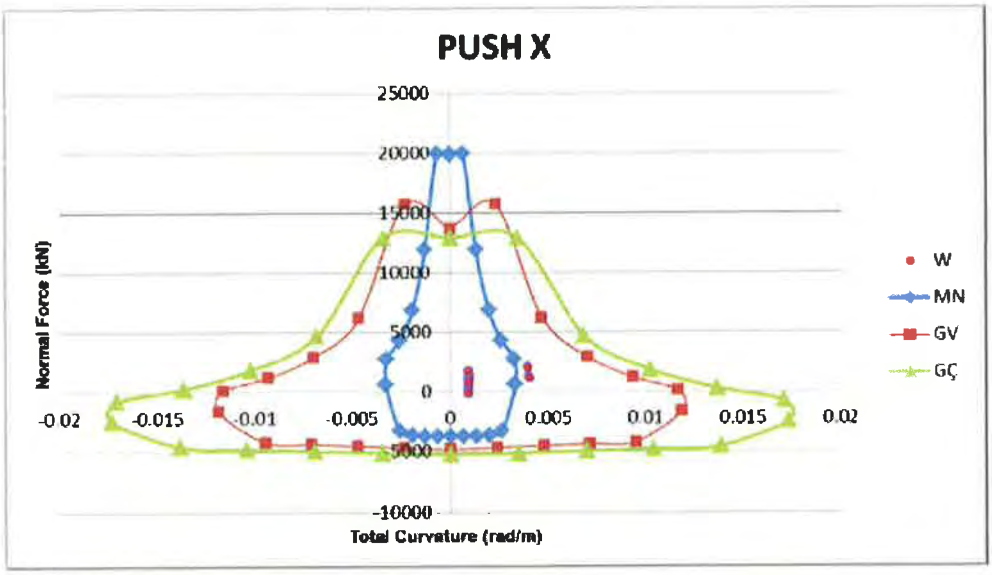


Figure 3.20a X Direction Pushover Analysis Shear Wall Assessment Results (Retrofitted Building-Existing Shear Walls-MCE Earthquake)

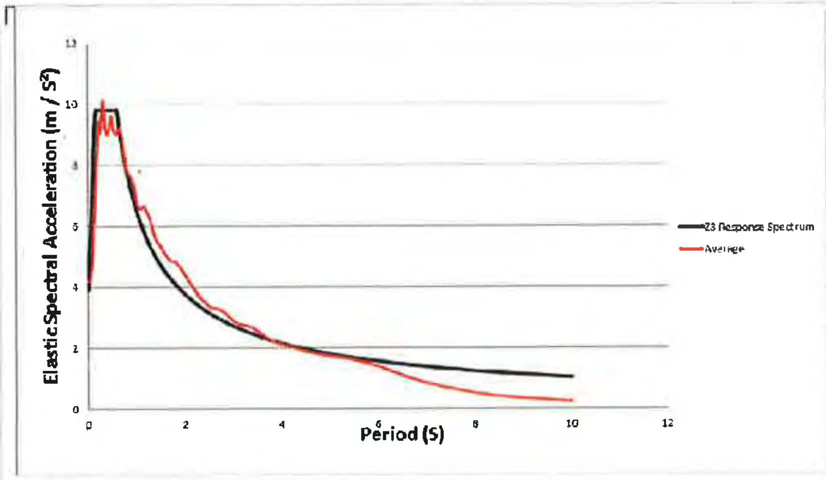
Comment: The beams of course are obligatory to investigate according to the Turkish Seismic Code 2007. Although it is known that some governmental bodies such as ISMEP do not require the beam investigation in detail as beams are secondary members in terms of structural stability and collapse control.

Meanwhile Promer gives all beam structural damage assessment data as tables in the end of their report.

Next, the 4 story building is investigated by non-linear time history analysis (THA).

In **THA** 7 different ground motion data are used according to the code. These ground motion waves are **scaled according to the design spectrum of DBE level** as designated by the code.

The average spectrum of 7 earthquakes scaled according to the **DBYBHY 2007** criteria shall be not less than 0.90 of the DBYBHY 2007 spectrum.



ZONE	PGA(m/s2)	
	FN	FP
BOLU	0.78	0.77
DUZCE	0.35	0.51
ERZINCAN	0.48	0.42
HECTOR	0.33	0.3
KOBE	0.28	0.27
KOCAELI	0.14	0.22
LANDER	0.28	0.22

Figure 2.5

In the THA results it was shown that all columns and shear walls were within minimum damage zone after MF retrofit for both orthogonal directions. As for the beams, similar to before (push over analysis) some beams has reached significant damage zone. The ratio should have stayed below 10% according to the code but in this case it is: 15/82=18,2%. (Table 3.14)

The report neglects this exceedance, claiming that beams are not majorly affecting the overall stability of the building and even the beam damage would positively contribute to the overall structural behavior by dissipating energy.

Comment: this condition may be accepted by some governmental bodies.

Table 3.14 Summary table of performance evaluation with time history analysis of 4 storey building with shear walls and retrofitted using MaSTER FRAME® for X and Y direction

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / Time History									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	68/82	14/82	--	10/10	-	--
2nd storey	36/36	--	--	67/82	15/82	--	10/10	-	--
1st storey	36/36	--	--	67/82	15/82	--	10/10	-	--
Ground Floor	36/36	--	--	68/82	14/82	--	10/10	-	--

It is noteworthy to show that the pushover curve has significantly changed after MF application in the 4 story model with shear walls:

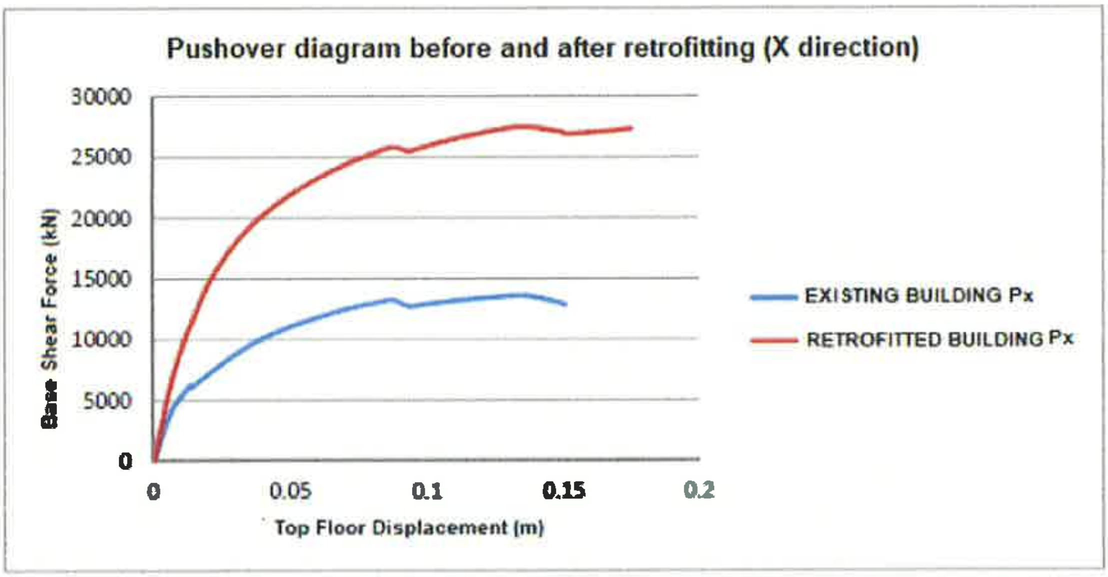


Figure 3.16a Pushover Diagrams Before and After Retrofitting (X Direction)

3 story RC building model (only moment frames)

Comment: In 3 story model the evaluation is very similar to previously explained 4 story model.

In this model, the structure didnt satisfy the code designated performance under DBE seismic level. As seen in Table 3.7 several columns and shear walls exceed the minimum damage level and some beams even reach advanced damage level in X direction (long direction in plan). In Y direction some beams exceeded minimum damage level but it is neglected and evaluated as the building satisfies the Code requirements in Y direction. Therefore there is no need to use the MCE seismic level. Building is evaluated as "retrofit required" in X direction.

Table 3.19 Summary table of performance evaluation with fixed first mode pushover analysis of existing 3 storey building without shear walls for X and Y direction

Existing 3-Story Structure / PUSH X							
	COLUMN				BEAM		
	Min Damage	Marked Damage	Advanced Damage	Collapse	Min Damage	Marked Damage	Advanced Damage
2nd storey	48/48	--	--	--	44/44	--	--
1st storey	25/48	2/48	6/48	15/48	35/44	9/44	--
Ground Floor	33/48	15/48	--	--	36/44	7/44	1/44

Existing 3-Story Structure / PUSH Y							
	COLUMN				BEAM		
	Min Damage	Marked Damage	Advanced Damage	Collapse	Min Damage	Marked Damage	Advanced Damage
2nd storey	48/48	--	--	--	44/44	0/44	--
1st storey	48/48	--	--	--	32/44	12/44	--
Ground Floor	48/48	--	--	--	27/44	10/44	7/44

After MF retrofit the nonlinear pushover analysis is performed and the performance level of the buildings is evaluated according to the damage level of each structural member. The type of MF is shown on Figure 3.14.

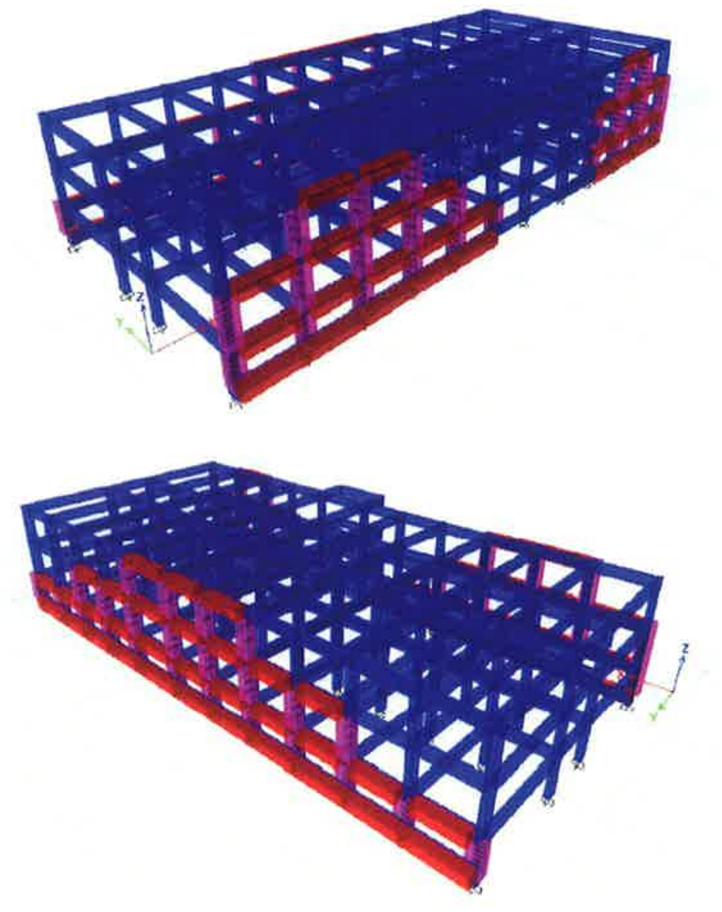


Figure 3.34 3D ETABS model of 3 storey structure retrofitted using MaSTER FRAME®

In the DBE seismic level (500 years) after MF retrofit following table that shows damage levels of each structural member has been obtained. From table we can understand that most of the structural members are in the minimum damage zone after MF retrofit. Only some beams are in significant damage zone (written as "marked damage" in report) According to the 2007 Seismic code, 10% of beams are allowed in the significant damage zone. In this case the ratio is 9,1% in X direction.

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / PUSH X									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	48/48	--	--	44/44	--	--	--	--	--
1st storey	48/48	--	--	44/44	--	--	--	--	--
Ground Floor	48/48	--	--	40/44	4/44	--	--	--	--

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME® (MaSTER FRAME's Members) / PUSH X									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	9/9	--	--	6/6	--	--	--	--	--
1st storey	17/17	--	--	14/14	--	--	--	--	--
Ground Floor	22/22	--	--	19/19	--	--	--	--	--

In the MCE seismic level (2500 years) only column damage levels are shown on graphs (these graphs are representing the axial load vs total end rotation of each member). Beam damage levels are not shown on graph or table form whatsoever. There is no summary table for columns either.

From the given figures it seems most columns are within the "minimum damage zone" however the percentage of the members exceeding this zone and also the ratio of total shear force value of members that are outside the minimum damage zone to the total story shear is not clear from these figures. Promer Engineering reports that Life Safety performance level is satisfied for columns and the beams are not investigated. Example graph is given in Figure 3.20a. It seems some shear walls exceeds the minimum damage level, however their contribution (ratio) to the story shear force is unknown. In the report Promer Engineering clearly states that column members satisfies the designated damage levels for the target performance level. (in Promer's Report 3.4.4.2)

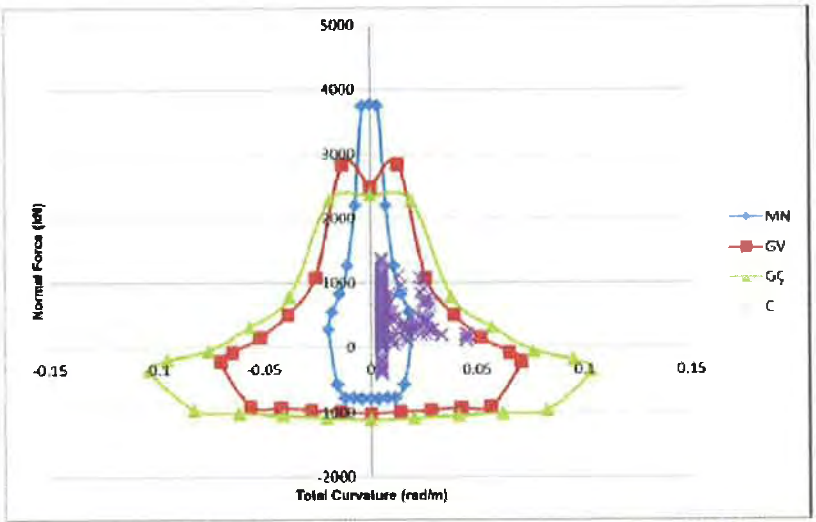


Figure 3.37d Y Direction Pushover Analysis Column Assessment Results (Retrofitted Building-Existing Column-MCE Earthquake)

Next, the 3 story building is investigated by non-linear time history analysis.

In the THA results it was shown that all columns and shear walls were within minimum damage zone after MF retrofit for both orthogonal directions. As for the beams, similar to before (push over analysis) some beams has reached significant damage zone. The ratio should have stayed below 10% according to the code but in this case it is: 23/82=28%. The report neglects this exceedance, claiming that beams are not majorly affecting the overall stability of the building even damaged beams may positively contribute to the overall performance. (in Report 3.4.5.2)
Comment: this condition may be accepted by some governmental bodies.

Table 3.26 Summary table of performance evaluation with time history analysis of 3 storey building without shear walls and retrofitted using MaSTER FRAME® for X and Y direction

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / Time History									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	48/48	--	--	80/82	2/82	--	--	--	--
1st storey	48/48	--	--	59/82	23/82	--	--	--	--
Ground Floor	48/48	--	--	54/82	28/82	--	--	--	--

It is noteworthy to show that the pushover curve has significantly changed after MF application in the 3 story model:

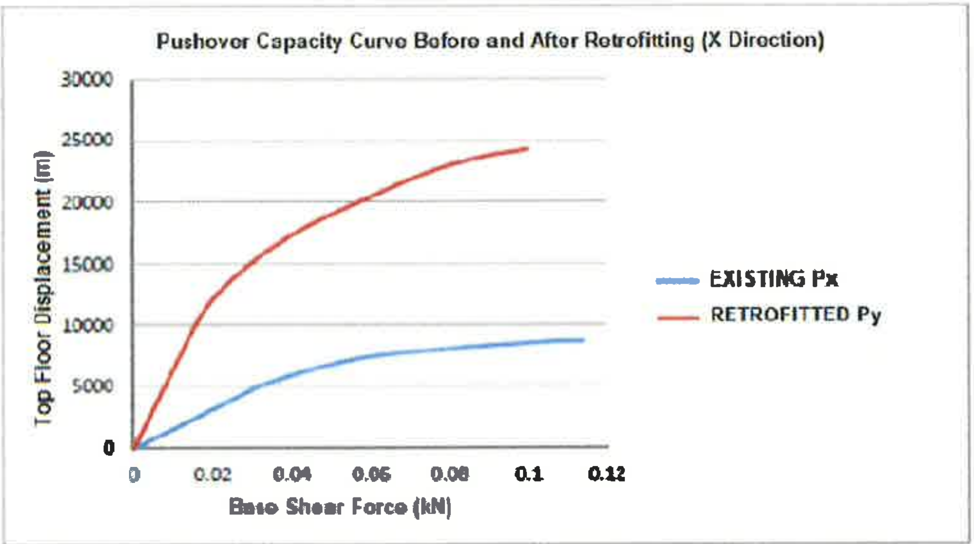


Figure 3.36a Pushover Diagrams of 3 Storey Building Before and After Retrofitting (X Direction)

Conclusion and comments:

Promer Engineering has completed a very comprehensive series of analysis for 2 types of RC school buildings. In general analysis results seems to satisfy the 2007 Turkish Seismic Code, however there are some neglected points such as details of shear force ratios of vertical members in significant damage zone or the performance evaluation of beams.

Some governmental organizations such as ISMEP or Ministry of National Education may accept these neglected points.

It should also be stated that RC buildings with shear walls may be challenging for MF retrofit. The amount and placement of MF does not improve the performance of beams that are connected to the shear walls.

ITU evaluation report is basically checking if the analysis and evaluation methods are strictly following the Code. The missed points will be reflected in the ITU report.

RETROFITTING REPORT OF TYPICAL SCHOOL BUILDING USING

MaSTER FRAME®

ProMer
Müşavirlik Mühendislik A.Ş.
Consultancy Engineering Inc.

DECEMBER 2018

Doc. No: ***401-MF-100-FDR-01***

REVISION TABLE

Date	*Rev.*	*Explanation*	*Revised*
01.12.2018	0	Sent for approval.	

ABBREVIATION

Definitions	Abbreviation	Explanation
MaSTER FRAME®	MF	
MaSTER Disk-Ankraj®	DA	
Time History Analysis	TH	
DBYBHY 2007	TEC 2007	Turkish code for the buildings constructed in Earthquake zones.
Design Based Earthquake	DBE	
Maksimum Considered Earthquake	MCE	

CONTENTS

EXPERT TEAM

Prepared By	**Structural Eng. M.Sc**	**Ali MAHDAVI**	**01.12.2018**	
Prepared By	**Structural Eng. M.Sc**	**Suat YILDIRIM**	**01.12.2018**	

1. INTRODUCTION

1.1. Subject

There were heavy life and economical losts in past earthquakes in our country which is in highly seismic zone. One of the biggest obstacles to prevent seismic retrofitting of the buildings is the need for evacuation. Japan Maeda Coorperation and Turkish partner GKMC (Garanti Koza Maeda Coorperation) set up a working in order to determine possibility to use the MaSTER FRAME® retrofitting technique ,which has proven itself in previous earthquakes in Japan, in Turkish public buildings. In addition to Istanbul Technical Univercity, Promer joined as analyser, Ministry of Environment and Urbanization and Miamoto joined to the group as observer.

1.2. Aim and Content of the Study

Two types of school buildings that are reinforced concrete 4 storey shear Wall-frame and reinforced concrete 3 storey frame type has choosen for the study. It is tried to find most frequently used school building types for the selected buildings. Selected Concrete and material quality is tried to be convenient with MaSTER FRAME® technique. Concrete quality down to 8 MPa has been studied in the tests performed in ITU and Maeda laboratories in order to determine target building types But 15 MPa.concrete quality is selected for this study in order to provide retrofitting only from outside of the buildings. That means targeted building material is determined to be higher than 14 MPa. It is determined from PROMER archive that percentage of school buildings having higher than 14 MPa is about 20-25 % of existing school buildings.

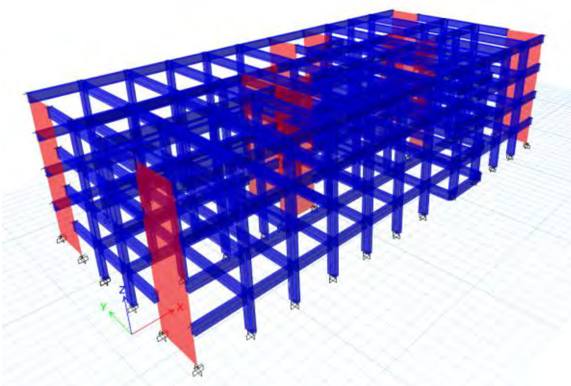


Figure 1.1 3D View 4 Storey Building with Shear Wall.

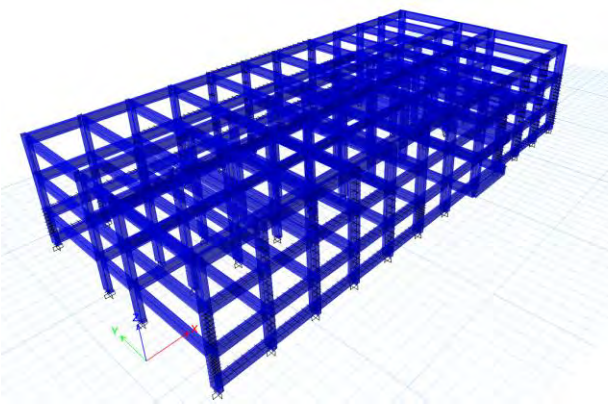


Figure 1.2 3D View 3 Storey Frame Type Building

1.3. Building Information

Table 1.1 and 1.2 contains summary for used building types.

Table 1.1 Summary of Typical 4 storey R/C building with Shear Wall

Building Name	:	**Typical 4 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Building Type	:	Reinforced Concrete with Shear Wall
Storey Height, Area, Number of Storey	:	2.9 m 760 m2 4 storey
Total Area	:	3040 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Participation Factor	:	0.60
Floor Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Floor Storey Loads	:	G=1.49 kN/m2, Q= 2.25 kN/m2
Wall Unit Weights	:	3.90 kN/m2
Foundation Type	:	Continuous Footing
Expected Performance	:	Immediate occupancy in the earthquake with 10 % exceedance probabilty in 50 years. And Life Safety in the earthquake with 2 % exceedance probabilty in 50 years
Used Cracked Section Factor	:	Column: I_{22},I_{33} =0.4 Beam : I_{33} = 0.4

Tablo 1.2 Summary of Typical 3 storey R/C building without Shear Wall

Building Name	:	**Typical 3 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Building Type	:	Reinfonced Concrete Frame Type
Storey Height, Area, Number of Storey	:	2.9 m - 760 m2 - 3 Storey
Total Area	:	2280 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Participation Factor	:	0.60
Floor Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Floor Storey Loads	:	G=1.49 kN/m2, Q= 2.25 kN/m2
Wall Unit Weights	:	3.90 kN/m2
Foundation Type	:	Continious Footing
Expected Performance	:	Immediate occupancy in the earthquake with 10 % exceedance probabilty in 50 years. And Life Safety in the earthquake with 2 % exceedance probabilty in 50 years
Used Cracked Section Factor	:	Column: I_{22},I_{33} =0.4 Beam : I_{33} = 0.4

2. PERFORMANCE BASED ASSESSMENT

2.1. General

Lack of methology for assessment of existing and retrofitted buildings in TEC 1998 is tried to be recovered adding chapter 7 in 2007 due to İzmit and Düzce Earthquakes in 1999 and it is called as TEC 2007 (DBYBHY 2007).
Modelling and analysis were performed via ETABS V16 software in retrofitting typical school buildings using MaSTER FRAME® study. TEC 2007 section 7 criterias and nonlinear modeling technique were used. Static first mode pushover analysis method is used for analysis.

2.2. Member Performance Limits and Damage Zones

TEC 2007 Section 7 defines two main types of failure; brittle and ductile.
Brittle failure is a sudden and uncontrollable failure and results due to insufficient shear capacity.
Ductile failure is seperated into 4 zones by 3 limits according to amount of deformation in members and amount of deformed members in the system.
Damage performance limits:
• Minimum Damage Limit (MN),
• Life Safety Damage Limit (GV),
• Collapse Limit (GÇ),

TEC 2007 section 7.3.2 Performance limits and damage zones are shown in Figure 2.1

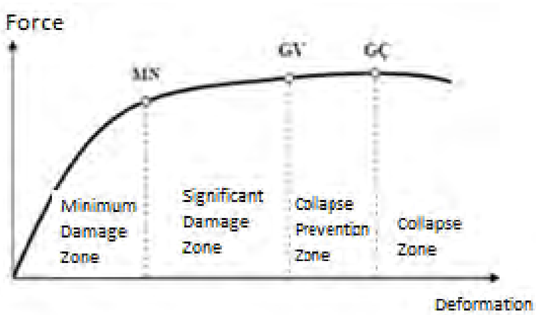


Figure 2.1 TEC 2007 Damage Zones

2.3. Building Earthquake Performans Levels

There are three performans level criterias in TEC 2007 accordings to the importance of the buildings.
These are Immediate occupancy, life safety and collapse.

Immediate Occupancy Performance Level: All earthquake load carrying members must be in immediate occupancy damage zone But only 10 % of beams are alloved to be in siginificant damage zone.

Life Safety Performance Level: Maximum 30% of the beams in the building elements and up to 20% of the shear force carried by the columns (40% on the top floor) can pass to the significant damage zone. The vertical load carrying members must be able to stand the vertical loads on them even though they have damage to some extend. Building can be strengthened in order to carry earthquke loads safely.

Collapse Prevention Performance Level: Maximum 30% of the beams in the building elements and up to 20% of the shear force carried by the columns can pass to the significant damage zone. Some of the vertical load carrying elements may have reached the normal force carrying capacity.

The structure is inconvenient in terms of life safety, but there should not be a total failure. It should be evaluated economically whether the structure will be strengthened or not.

Collapse Performance Level: As a result of the affecting load, the structure is not able to provide the level of performance collapse prevention. The elements in the structure have reached the capacity of load carrying capacity. Those who do not reach the capacity will reach their capacities under the effect of the next light intensity earthquake and will loose their strength.

2.4. Target Earthquake Levels for Buildings

According to **DBYBHY 2007**, three different levels of earthquakes were used to determine the performance of structures**.**. These are service, design (DBE) and maksimum considered earthquake (MCE).

Service earthquake: The ground motion with 50 % exceedance probability in 50 years. The approximate return period is 72 years. The effect of this earthquake is about half of the design earthquake described below

Design earthquake: The ground motion with 10 % exceedance probability in 50 years
. The approximate return period is 475 years. This earthquake is the main design earthquake in 1998 and DBYBHY 2007.

Maksimum considered earthquake: The ground motion with 2 % exceedance probability in 50 years. The approximate return period is 2475 years. The effect of this earthquake is about 1.5 times the design earthquake.

The earthquakes and the performance level required to determine the earthquake performance of the existing or strengthening buildings are given in Table 2.1.

Tablo 2.1 DBYBHY 2007 Minimum Performance Targets for Buildings

The usage purpose and the Type of the Building	*Probability for the Earthquake to be exceeded*		
	50 % in 50 years	*10 % in 50 years*	*2 % in 50 years*
The buildings that should be used after earthquakes: Hospitals, heath facilities, fire stations, communications and energy facilities, transportation stations, provincial or district administrative bodies, disaster management centers etc.	–	IO	LS
The buildings that people stay in for a long time period: Schools, accommodations, dormitories, pensions, military posts, prisons, museums, etc.	–	IO	LS
The buildings that people visit densely and stay in for a short time period: cinema, theatre and concert halls, culture centers, sports facilities	IO	LS	–
Buildings containing hazardous materials: The buildings containing toxic, flammable and explosive materials and the buildings in which the mentioned materials are stored.	–	IO	CP
Other buildings: The buildings that does not fit the definitions given above (houses, offices, hotel, tourist facilities, industrial buildings, etc.)	–	LS	–

IO: Immediate Occupancy **LS:**Life Safety **CP:** Collapse Prevention

- In this study, Immediate Occupancy performance level for DBE and life safety performance level for MCE will be checked using nonlinear static constant first mode pushover analysis. Additionally nonlinear time history ananlysis will be performed for confirmation purpose.

2.5. General Principals and Rules for Earthquake Calculation

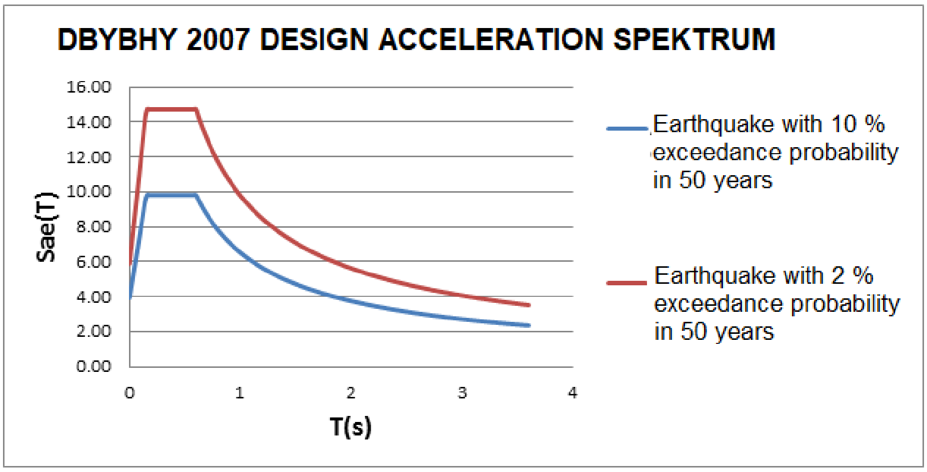
In the following, general principles and rules to be used for both the linear elastic and nonlinear calculation methods of existing or retrofitted buildings as per **DBYBHY 2007** are described.

- The building importance coefficient will not be applied in the earthquake calculation (**I** = 1.0).
- Earthquake forces shall be applied to the building in both x-y directions and in both + - directions separately.
- Soil properties to be used in earthquake calculation will be determined according to **DBYBHY 2007** chapter 6.
- The effective bending rigidity of the cracked section is described below. Linear interpolation can be done for intermediate values of N_D.
  Beams $(EI)_e = 0.40\ (EI)_0$
  Column and Shear Walls, if $N_D/(A_c f_{cm}) \leq 0.10$ then: $(EI)_e = 0.40\ (EI)_0$
  İf $N_D/(A_c f_{cm}) \geq 0.40$ then: $(EI)_e = 0.80\ (EI)_0$

2.6. Nonlinear Determination of Building Performans

Analysis methods used to determine building performance by nonlinear methods are incremental constant first mode equivalent earthquake pushover method, incremental mode coupling pushover method and time history method.

➢ In this study, incremental constant first mode equivalent earthquake pushover method and, time history analysis method will be used in order to assess existing and retrofitted case of two types of school buildings using MaSTER FRAME® technique. One is 4 storey consisting shear walls and the other one is 3 storey frame type.



Soil Type	Z3
A_0	0.4
I	1
g	9.81
TA	0.15
TB	0.6

Figure 2.1.a DBYBHY 2007 Design Acceleration Spektrum

2.6.1. Calculation steps to be used in the evaluation of performance analysis by incremental equivalent earthquake push over analysis

The steps in nonlinear performance evaluation to be performed by using Incremental pushover analysis according to **DBYBHY 2007** are described in the following section.

a) a) A static analysis is done under the vertical load of the structure which is used in earthquake analysis before starting the pushover analysis. The results of this analysis are considered as the initial conditions of the incremental push analysis.

b) In case the incremental equivalent earthquake load method is used in incremental pushover analysis, the modal capacity diagram of the first (dominant) mode, whose axes are defined as “modal displacement-modal acceleration”, is obtained. With this diagram, the modal target displacement of the first (dominant) mode is determined by taking into account elastic behavior spectrum specified in the code and the changes in this spectrum for the different exceedence probability. In the last step, plastic deformation (plastic rotations) and internal forces corresponding to target displacement are calculated.

2.6.1.1. Pushover analysis with equivalent earthquake load method

The purpose of the Pushover with incremental Equivalent Earthquake Load Method is to perform nonlinear pushover analysis under the influence of equivalent earthquake loads incrementally monotonically up to the boundary of the earthquake request, so as to be proportional to the first dominant vibration mode shape. Due to the fact that our building type is the first mode dominant and has a smooth geometry, pushover with equivalent earthquake load method is used as the first step of performance analysis with nonlinear methods. At each step of the pushover analysis following the vertical load analysis, the displacement, plastic deformation and internal force increments and the cumulative values of the structural system and the corresponding maximum values in the last step are calculated.

During the incremental pushover analysis, it is assumed that the equivalent earthquake load distribution remains constant regardless of the plastic hinges in the structural system. In this case, the load distribution is defined propotional to the value obtained with the value product of first step elastic behaviour natural vibration mod shape (dominant in the earthquake direction) amplitude and corresponding mass. In buildings, floors were idealized as rijid diaphragms, two horizontal translation perperdicular to each other and the rotation around the vertical axis at the center of mass are considered as first dominant mode shape vibration amplitudes.

The pushover curve with ordinates “top floor peak displacemet – base shear force” is obtained with pushover analysis made according to the constant load distribution. Top Floor peak displacement is the displacement in each push step at the center of mass on the top floor in the considered earthquake direction. Base shear force is the sum of earthquake loads at each push step calculated at base level in the considered earthquake direction. Modal capacity diagram with ordinates “modal displacement-modal acceleration” can be obtained with the ordinate transformation applied to the pushover curve as follows. Relations given for sampling purpose for the considered X-direction.

(a) Modal acceleration $a1^{(i)}$ is obtained as follows at $(i)^{th}$ push step in considered earthquake direction for the considered dominant first mode.

$$a_1^{(i)} = \frac{V_{x1}^{(i)}}{M_{x1}}$$

In the equation Vx1(i) represents total base shear at (i)th push step in considered X earthquake direction for the dominant first mode, Mx1 represents effective mass defined for elastic behaviour in considered X earthquake direction for the dominant first mode.

(b) Modal displacement $d_1^{(i)}$ is obtained from the following equation at (i)th push step in considered X earthquake direction for the dominant first mode.

$$d_1^{(i)} = \frac{u_{xN1}^{(i)}}{\Phi_{xN1}\,\Gamma_{x1}}$$

Modal contribution multiplier Γ_{x1} for the first dominant mode in considered direction is calculated using L_{x1} defined in x direction at start step for elastic behaviour and M_1 , modal mass defined for the 1. Natural vibration mode as follows.

$$\Gamma_{x1} = \frac{L_{x1}}{M_1}$$

After transformation of pushover curve into a modal capacity diagram, the defined spectrum curve is converted to the elastik behaviour spectrum. Modal displacement demand (for first dominant mode in considered direction) is determined after necessary transformations. Modal displacement demand $d_1^{(p)}$ is equal to nonlinear spectral displacement S_{di1}.

$$d_1^{(p)} = S_{di1}$$

Linear non-elastic spectral displacement, S_{di1}, is obtained in the first step of the pushover analysis by the following equation depending on the linear elastic spectral displacement S_{de1} corresponding to the dominant period calculated on the basis of linear elastic behavior

$$S_{di1}=C_{R1}S_{de1}$$

Spectral displacement ratio C_{R1} in the equation is calculated depending on the value start period $T_1^{(1)}$ as follows.

In the case of T_1 start period is equal or bigger than characteristic period in the acceleration spectrum T_B , nonlinear spectral displacement S_{di1} is equal to linear elastic displacement S_{de1} according to the equal displacement rule. . Accordingly;

$$C_{R1} = 1$$

Figure 2.2 shows the behaviour spectrum with coordinates and modal capacity diagram for the first dominant vibration mode.

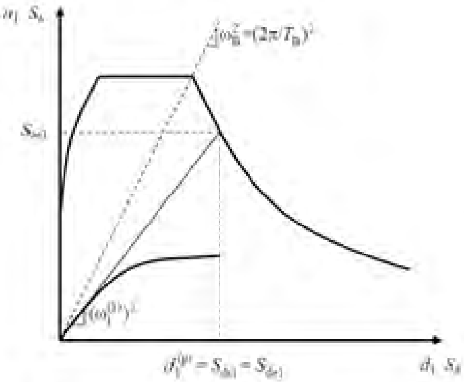


Figure 2.2 DBYBHY 2007 Atth. 7C Definition of Performans displacement. $T^{(1)}>T_{(B)}$

If the T_1 start period is shorter than the characteristic period $T_{(B)}$ in the acceleration spectrum, the spectral displacement ratio CR1 is calculated by successive approach.

(a) Modal capacity diagram as a result of pushover analysis, as shown in the figure below, is converted to a bilinear diagram. The slope of this starting line of this diagram is taken as the slope at the first step (i=1) which is eigenvalue of the first $(\omega_1^{(1)})^2$, $(T_1 = 2\pi / \omega_1)$.

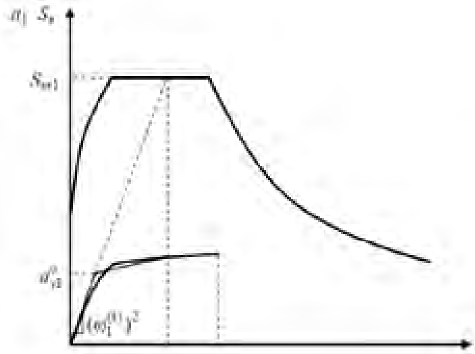


Figure 2.3 DBYBHY 2007 Atth. 7C Definition of Performans displacement $T^{(1)} \leq T^{(B)}$

(b) In the first step of the successive approach, assuming C_{R1} =1, the coordinates of the equivalent yield point are determined by the equal fields rule. C_{R1} is defined as follows based on a^{o}_{y1} seen in the following figure:

$$C_{R1} = \frac{1 + (R_{y1} - 1)\, T_B / T_1^{(1)}}{R_{y1}} \geq 1$$

In this relation, R_{y1} shows the strength reduction coefficient of the first mode.

$$R_{y1} = \frac{S_{ae1}}{a_{y1}}$$

Coordinates of equivalent yield point is determined using the calculated C_{R1} and S_{di1} as shown in the figure below by using equal fields rule. Accordingly a_{y1} , R_{y1} and C_{R1} are recalculated. In the step where the results obtained in two consecutive steps approach to an acceptable tolerance, the successive approach is terminated.

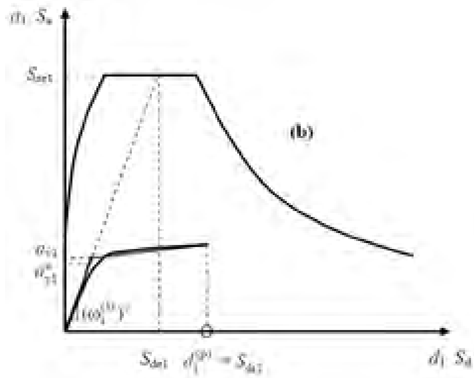


Figure 2.4 DBYBHY 2007 Atth. 7C Definition of Performans displacement $T^{(1)} \leq T_{(B)}$

The peak displacement demand in X earthquake direction (target displacement) is obtained by the following equation $u^{(p)}_{xN1}$

$$u_{xN1}^{(p)} = \Phi_{xN1} \Gamma_{x1} d_1^{(p)}$$

All other demand values (displacement, deformation and internal forces) that correspond to the pushed step up to the target displacement are obtained from the existing pushover analysis file or calculated by a new pushover analysis performed until the peak displacement targett is reached.

$$\phi_p = \frac{\theta_p}{l_p}$$

Equivalent yield curvature defined by bilinear moment curvature relations obtained using concrete and reinforcing steel stress strain relations (ϕ_y) and plastic curvature demand (ϕ_p) is added in order to obtain total curvature in the section (ϕ_t).

$$\phi_t = \phi_y + \phi_p$$

The unit deformation demand in the concrete and the reinforcement steel in the reinforced concrete structures, is calculated from the moment curvature relation according to the total curvature demand calculated from analysis. The calculated concrete and reinforcement unit deformation demands are compared with limit values given in section 2.6.1.2 in order to obtain member damage levels.

2.6.1.2. Unit sectional deformation capacities of reinforced concrete members.

The material deformation limit values In **DBYBHY 2007**, to be taken into consideration in determining the damage levels of ductile elements are summarized below..

a) Minimum Damage Level (MN):

$(\varepsilon_{cu})_{MN} = 0.0035$; $(\varepsilon_s)_{MN} = 0.010$

b) Life Safety Damage Level (GV):

$(\varepsilon_{cu})_{GV} = 0.0035 + 0.01(\rho_s / \rho_{sm}) \leq 0.0135$; $(\varepsilon_s)_{GV} = 0.040$

c) Collapse Damage Level (GÇ)

$(\varepsilon_{cu})_{GC} = 0.004 + 0.014(\rho_s / \rho_{sm}) \leq 0.018$; $(\varepsilon_s)_{GC} = 0.060$

2.6.2. Non-linear time history analysis method

The aim of the Nonlinear Time History Method is to integrate the motion equation of the system step by step, considering the nonlinear behavior in the structural system. During the analysis, the displacement, plastic deformation and internal forces and the maximum values corresponding to the earthquake demand are calculated. Although the structural properties of the building is appropriate for constant first mode pushover analysis, extra nonlinear time history analysiss are performed to verify the results of pushover analysis

2.6.3. Analizlerde kullanılacak deprem kayıtlarının seçilmesi

The conditions that the acceleration records should be used in the analysis according to the Earthquake Code **DBYBHY 2007**, will be as follows.

a) The duration of the strong motion shall not be less than 5 times the first natural vibration period of the building and less than 15 seconds.

b) The mean spectral acceleration values of earthquake ground motion corresponding to zero period shall not be smaller than A_0g.

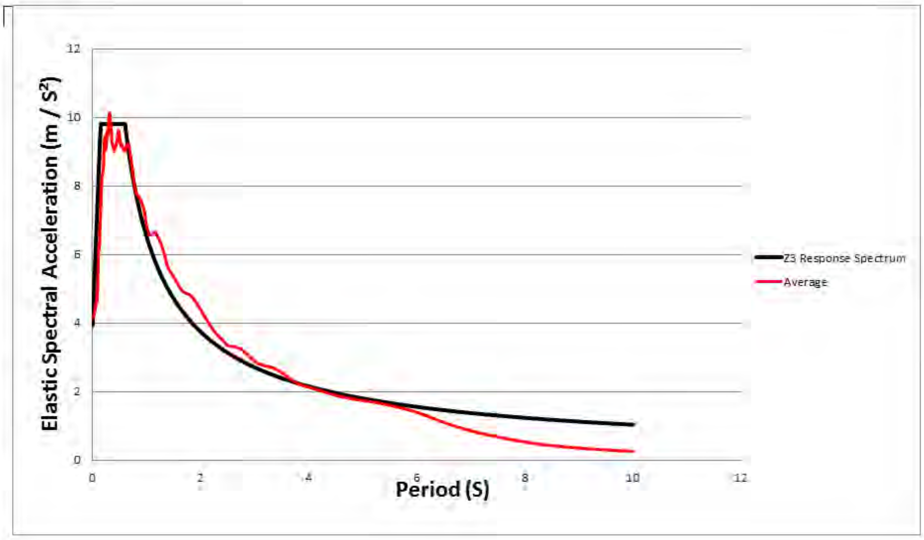
c) The average of the spectral acceleration values for the 5% damping ratio according to each acceleration record produced artificially, according to the domimant period T1 in the earthquake direction for the periods between 0.2 T1 and 2 T1, Sae(T) will not be less than 90% of elastic spectral accelerations defined in **DBYBHY 2007** Section 2.4.

Scaled BOLU, DÜZCE, ERZİNCAN, HECTOR, KOBE, KOCAELİ, LANDER acceleration records were used in time history analysis.
The conditions of the earthquake regulation were complied with in selecting the earthquake records used in the analysis. According to the first condition, the duration of earthquakes must be more than five times 0.283 s and longer than 15 s. The duration of artificially produced earthquake records is much higher than the seismic periods required by the regulation.
According to the second of the conditions in the earthquake regulation, the average of the spectral acceleration values of the selected earthquake records corresponding to the zero period will not be smaller than A_0g. The spectral acceleration values corresponding to zero period are given in Table 2.2. It is shown in the table that the second condition for the earthquake with exceedence probability 10% in 50 years is achieved.

Tablo 2.2 Suitability Check for Used Earthquake Acceleration Records for Time History Analysis.

EARTHQUAKE	duration	Total Number of Steps	Elastic Spectral Acceleration Value (m / s2) for T=0	
BOLU-FN-Scaled	54	5400	4.46	
DUZCE-FN-Scaled	25	5000	3.70	
ERZİNCAN-FN-Scaled	20	4000	4.38	
HECTOR-FN-Scaled	45	4500	6.17	
KOBE-FN-Scaled	40	4000	4.42	
KOCAELİ-FN-Scaled	25	5000	4.40	
LANDER-FN-Scaled	43	2150	4.63	
BOLU-FP-Scaled	54	5400	3.74	
DUZCE-FP-Scaled	25	5000	3.28	
ERZİNCAN-FP-Scaled	20	4000	3.89	
HECTOR-FP-Scaled	45	4500	0.10	
KOBE-FP-Scaled	40	4000	41.01	
KOCAELİ-FP-Scaled	25	5000	0.00	
LANDER-FP-Scaled	43	2150	0.00	
		Average:	**6.01**	> 0.4*9.81=3.92

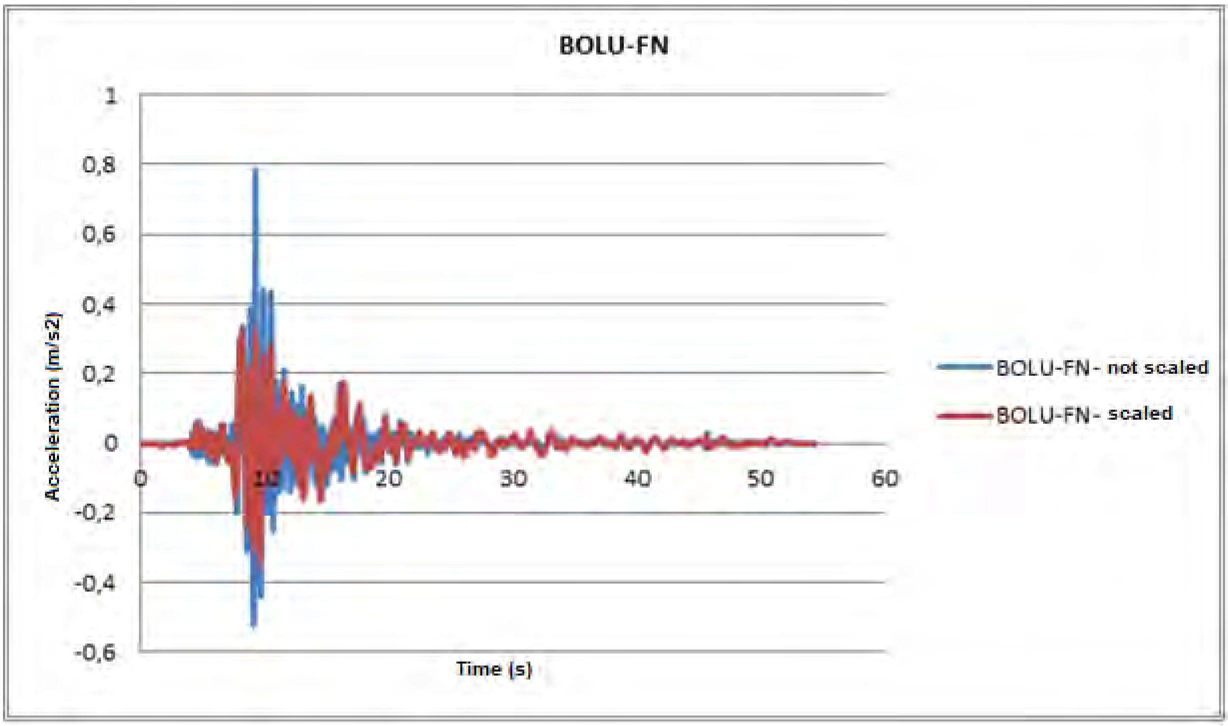
The average spectrum of 7 earthquakes scaled according to the **DBYBHY 2007** criteria shall be not less than 0.90 of the DBYBHY 2007 spectrum.



ZONE	PGA(m/s2)	
	FN	FP
BOLU	0.78	0.77
DUZCE	0.35	0.51
ERZİNCAN	0.48	0.42
HECTOR	0.33	0.3
KOBE	0.18	0.27
KOCAELİ	0.14	0.22
LANDER	0.28	0.22

Figure 2.5

Within the scope of the study, the scaled and not-scaled acceleration records of the earthquakes (FN) and parallel (FP) direction records of the earthquakes used for the time history analysis are given in Figures 2.6-2.17..



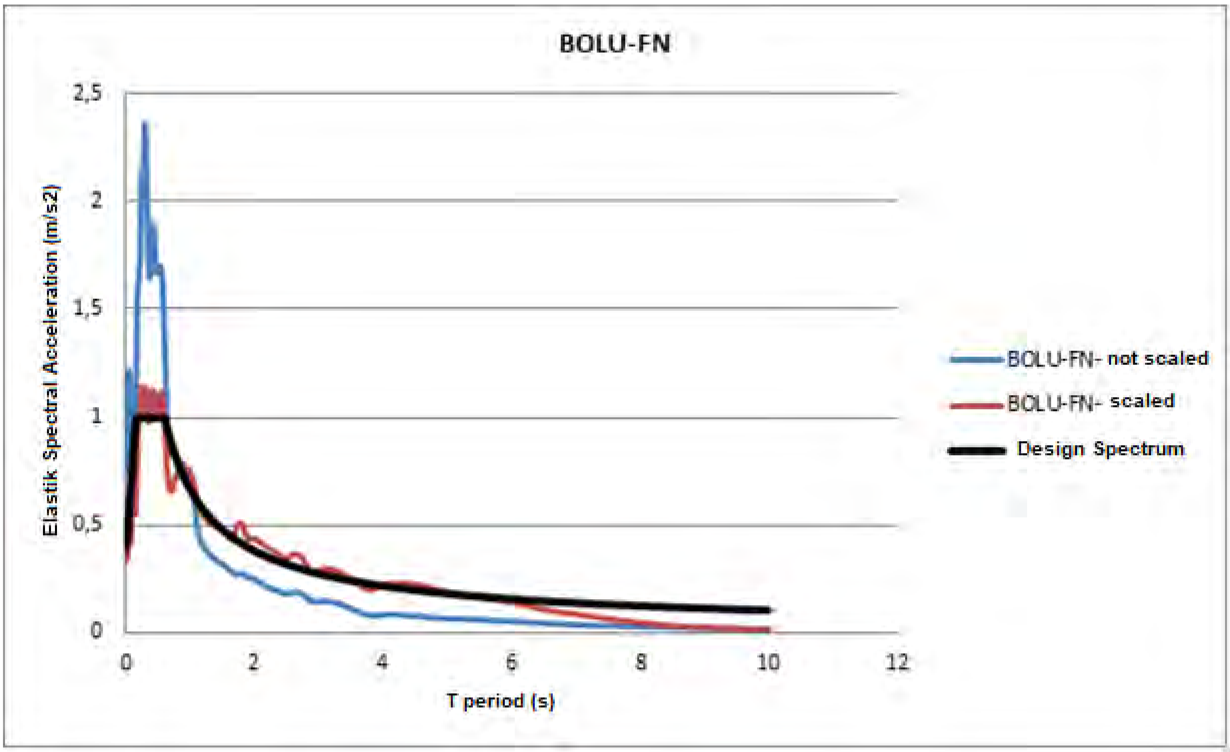
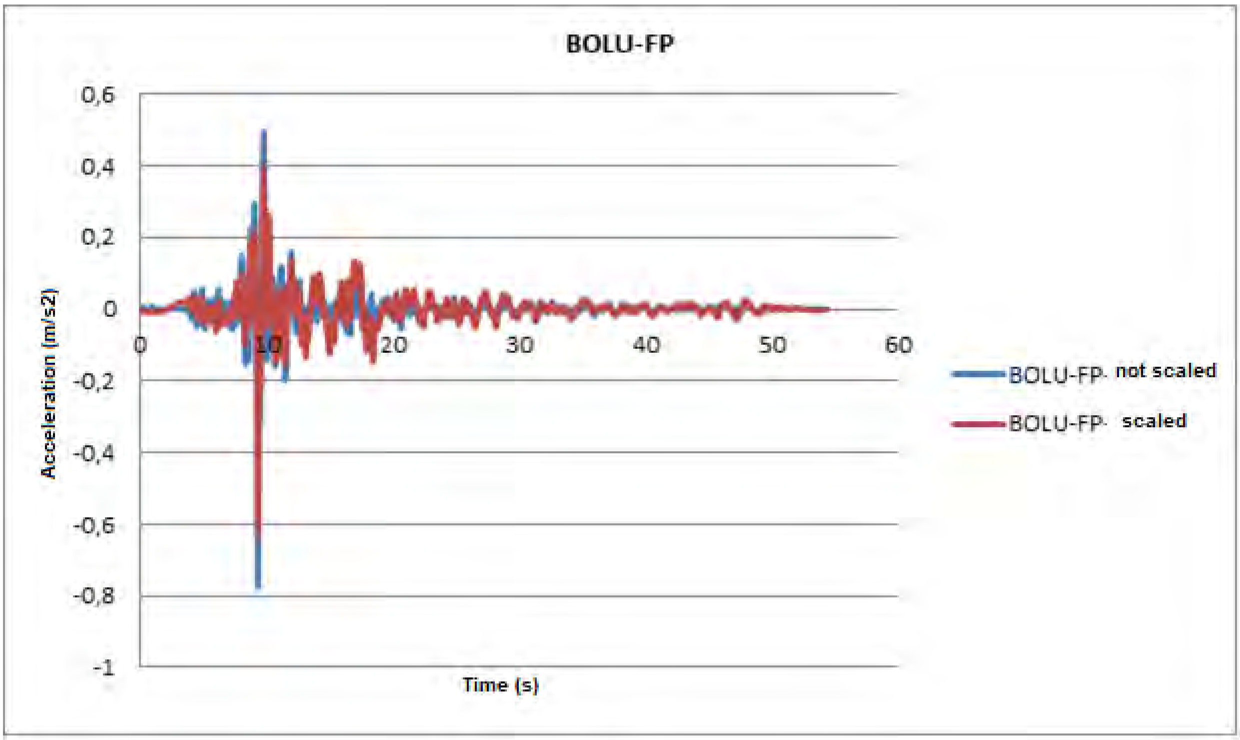


Figure 2.6 Bolu FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



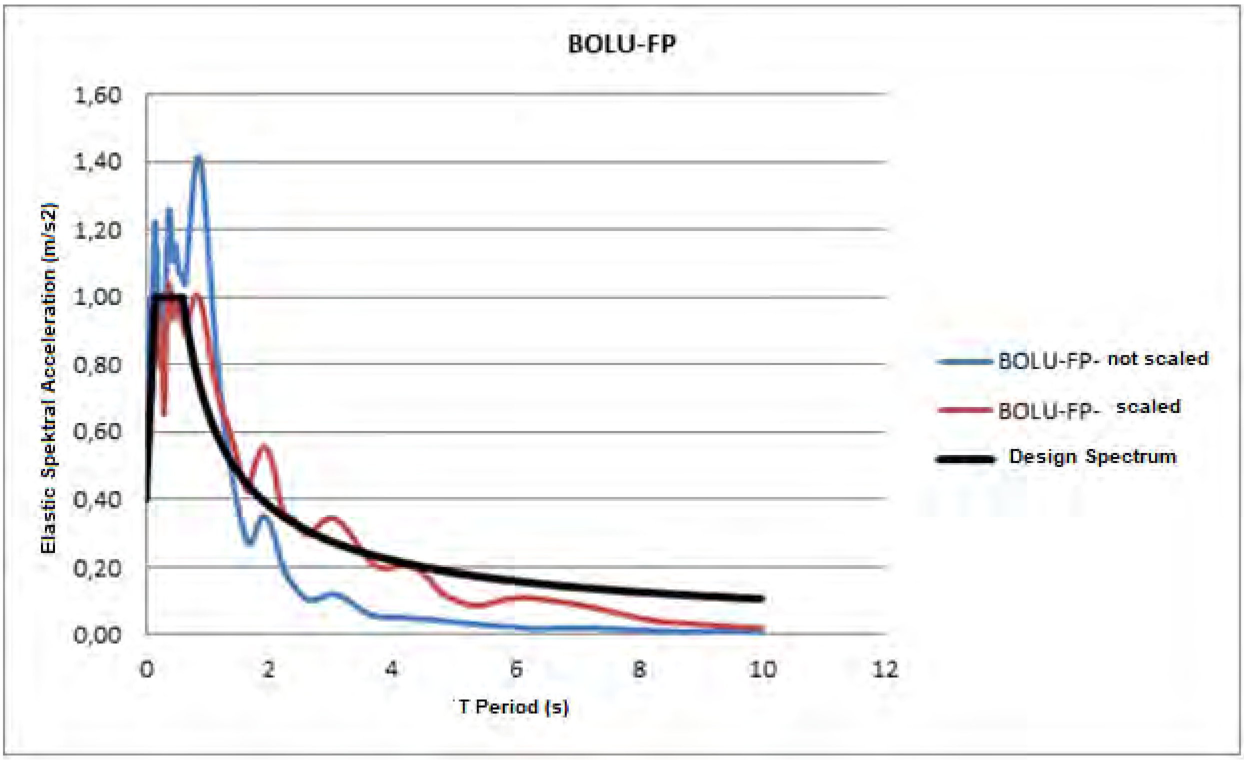


Figure 2.7 Bolu FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled

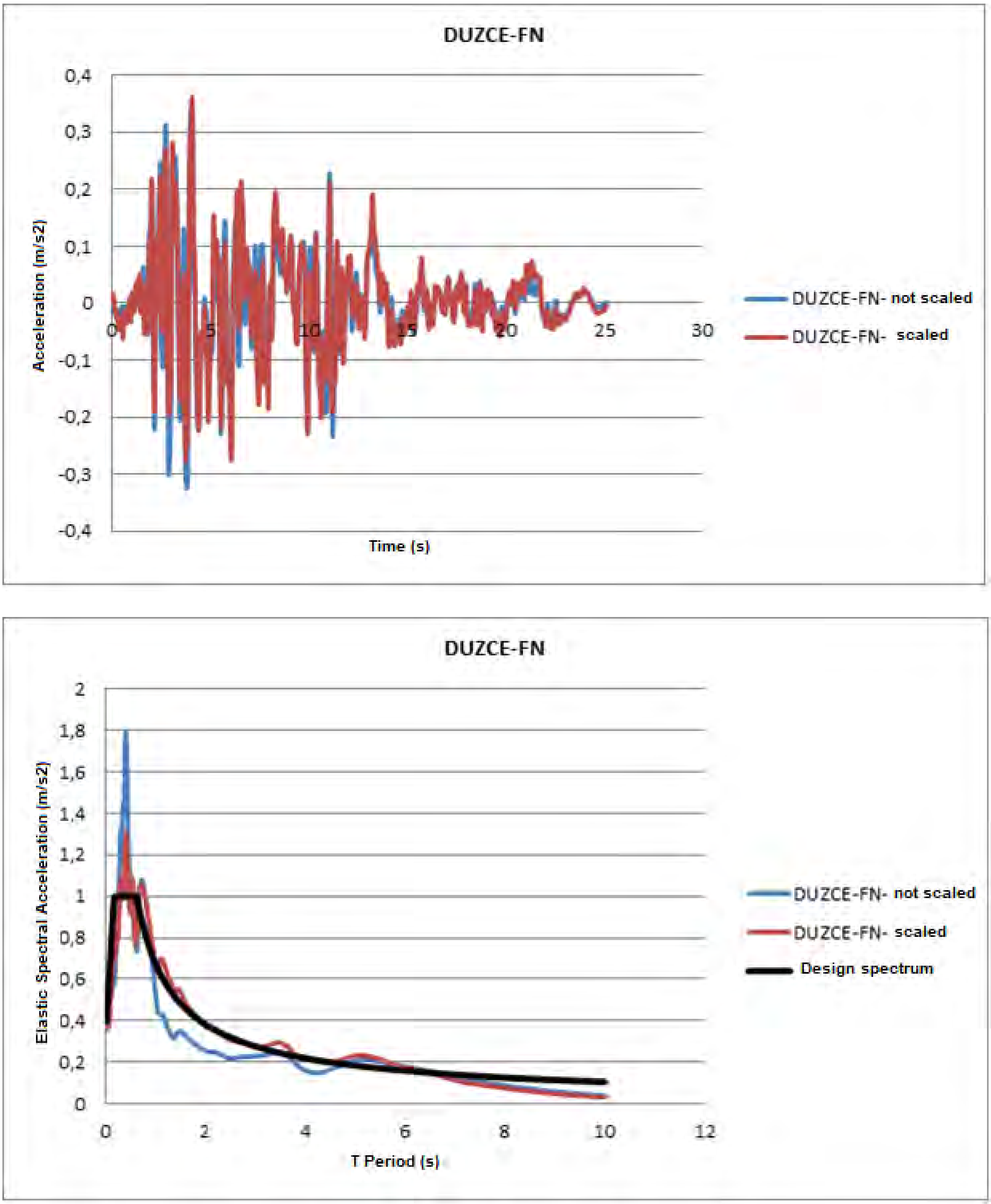
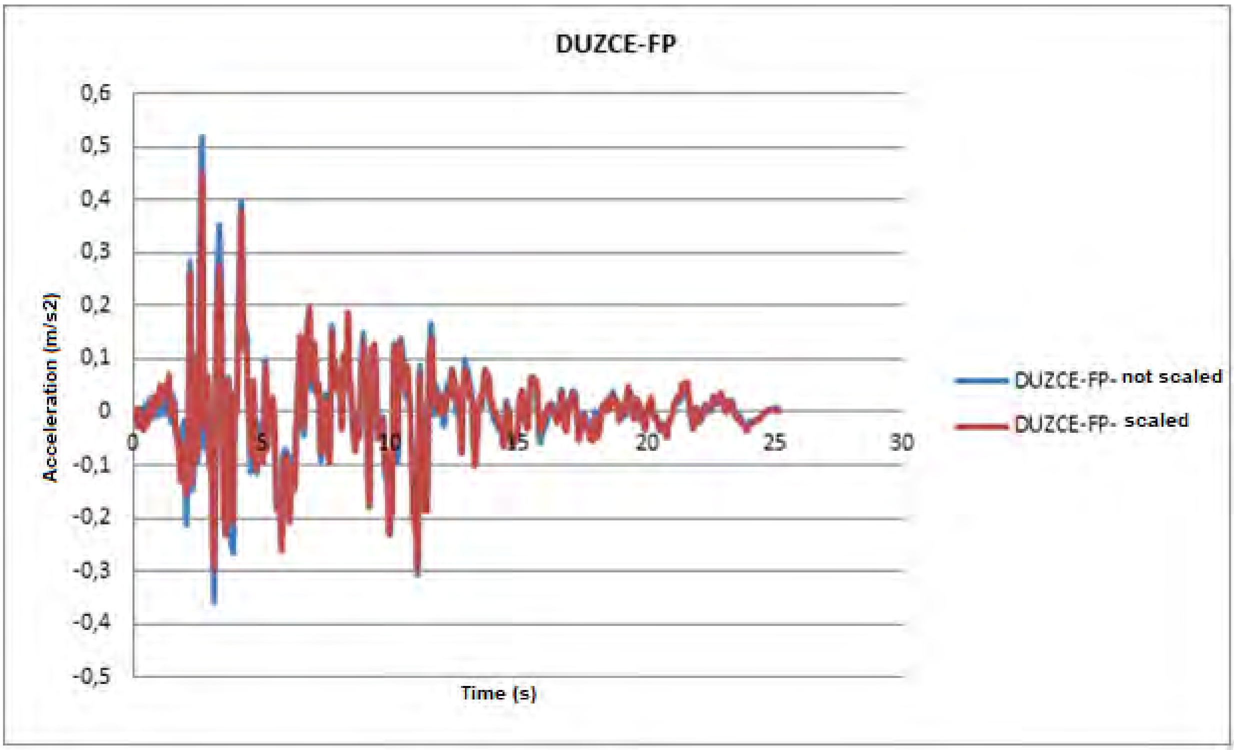


Figure 2.8 Düzce FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



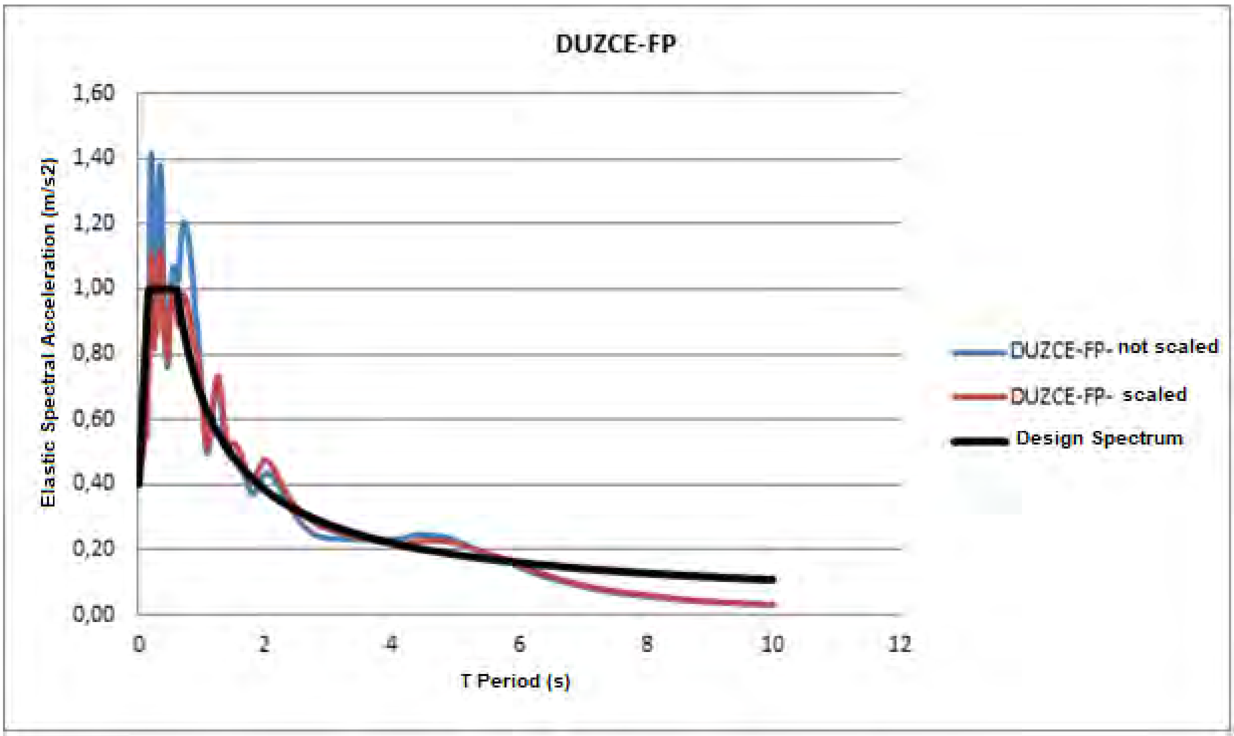
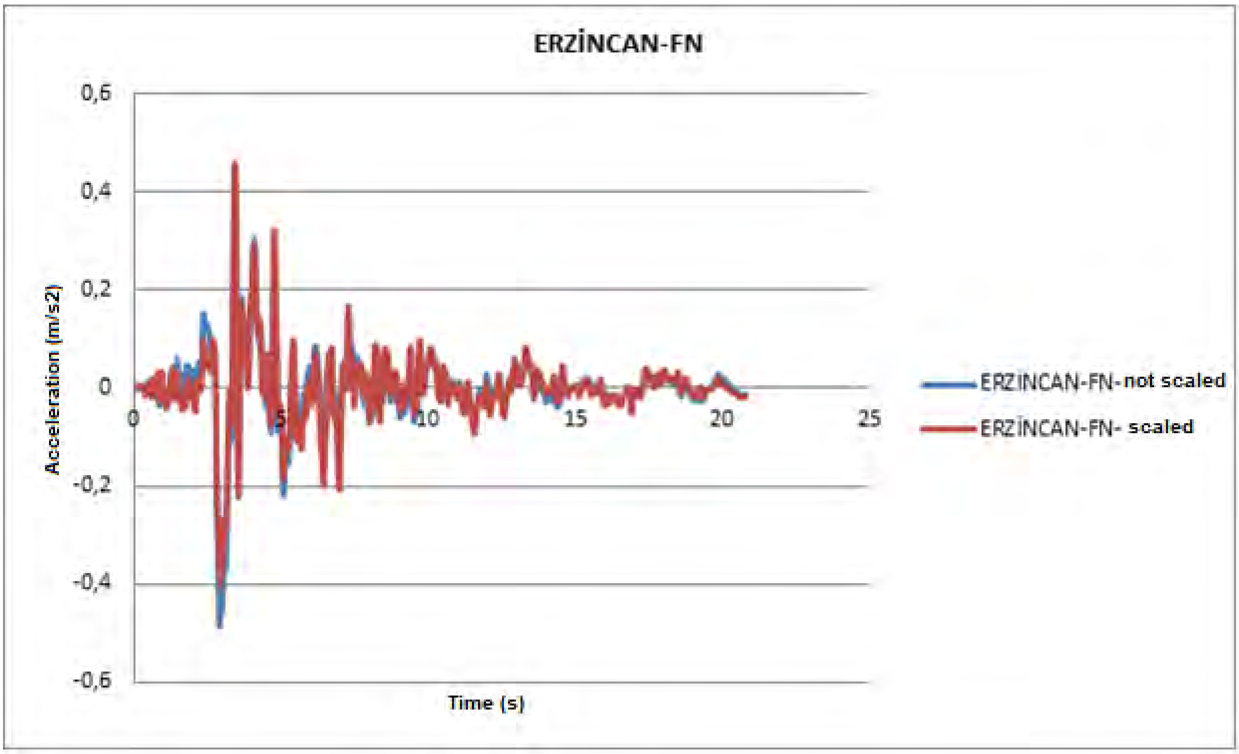


Figure 2.9 Düzce FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



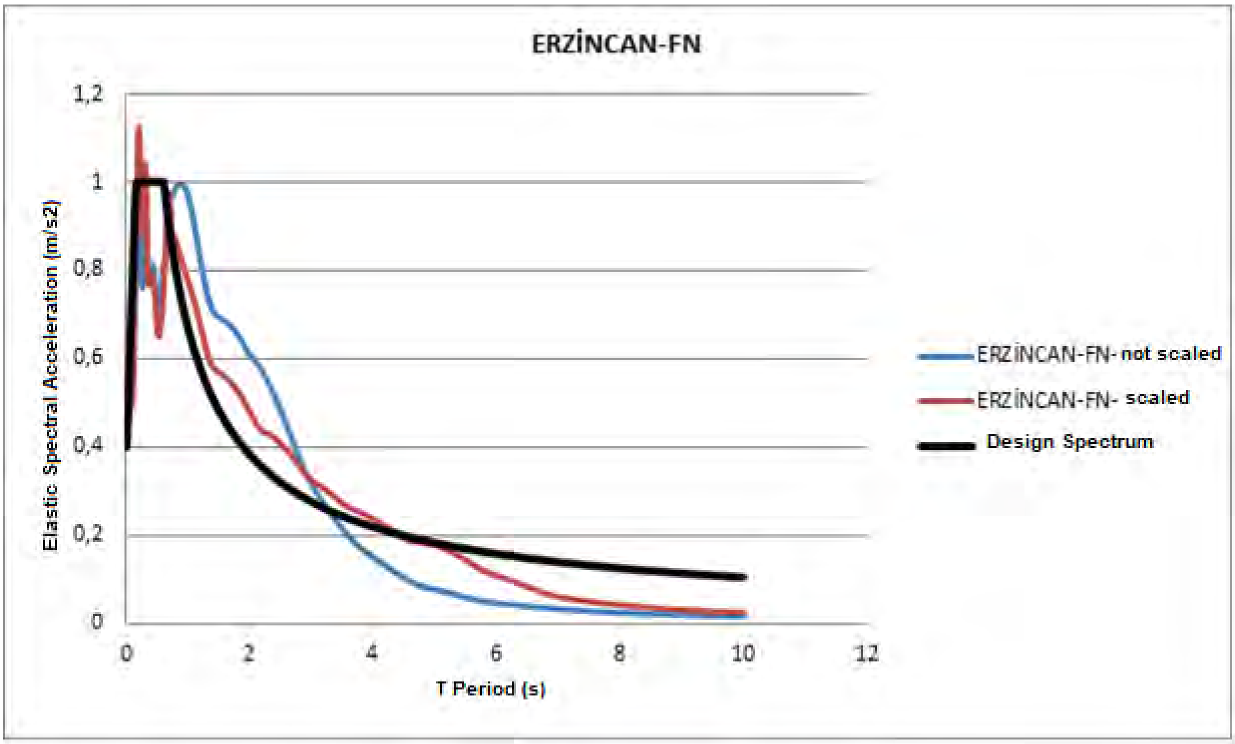
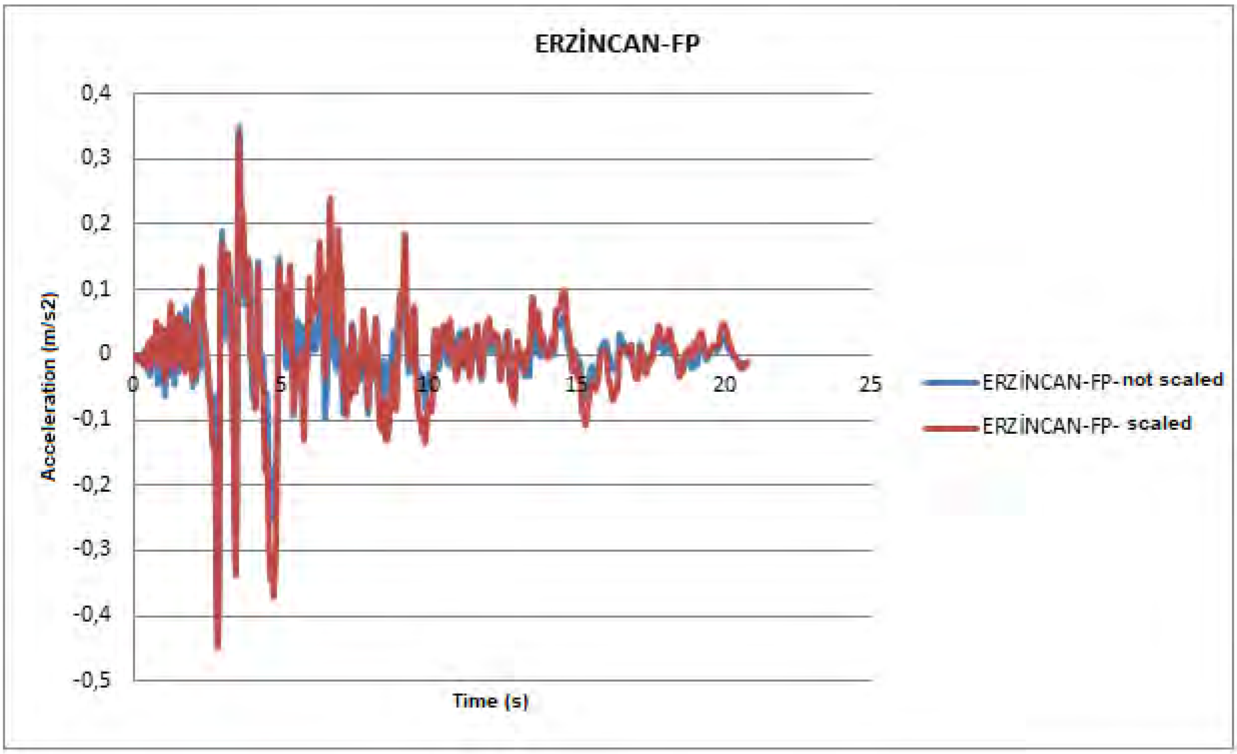


Figure 2.10 Erzincan FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



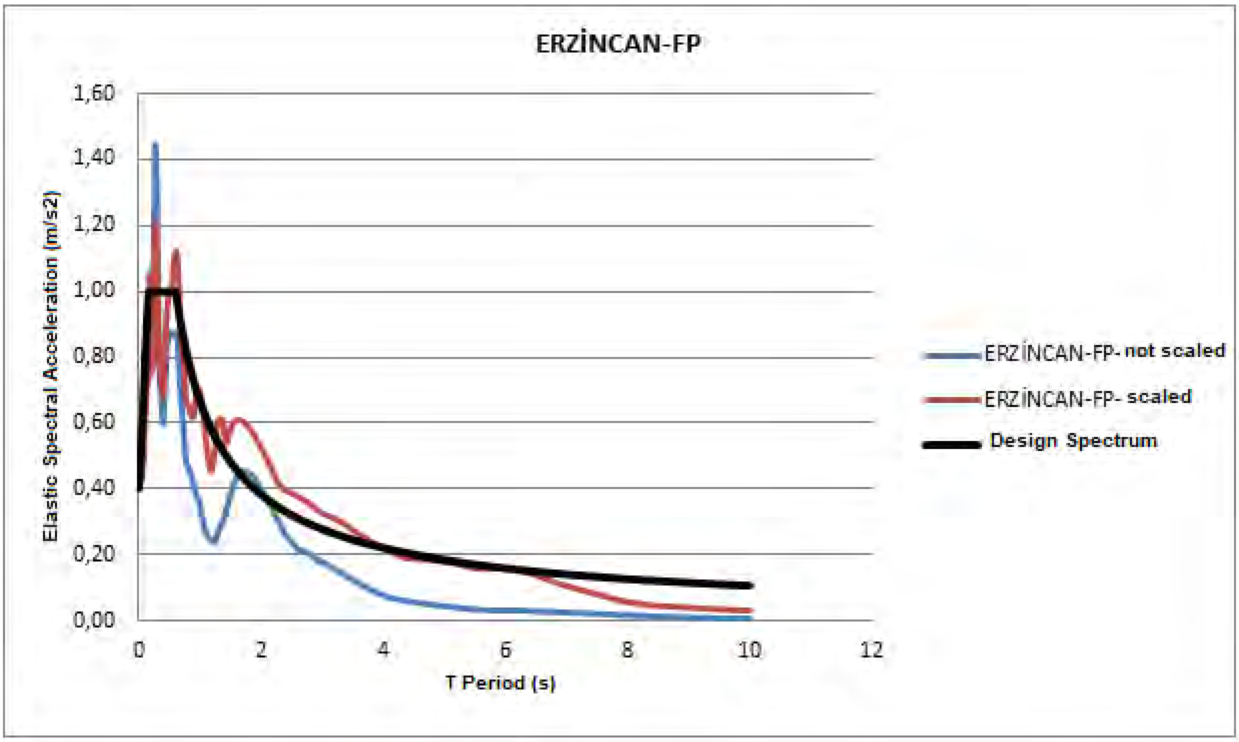
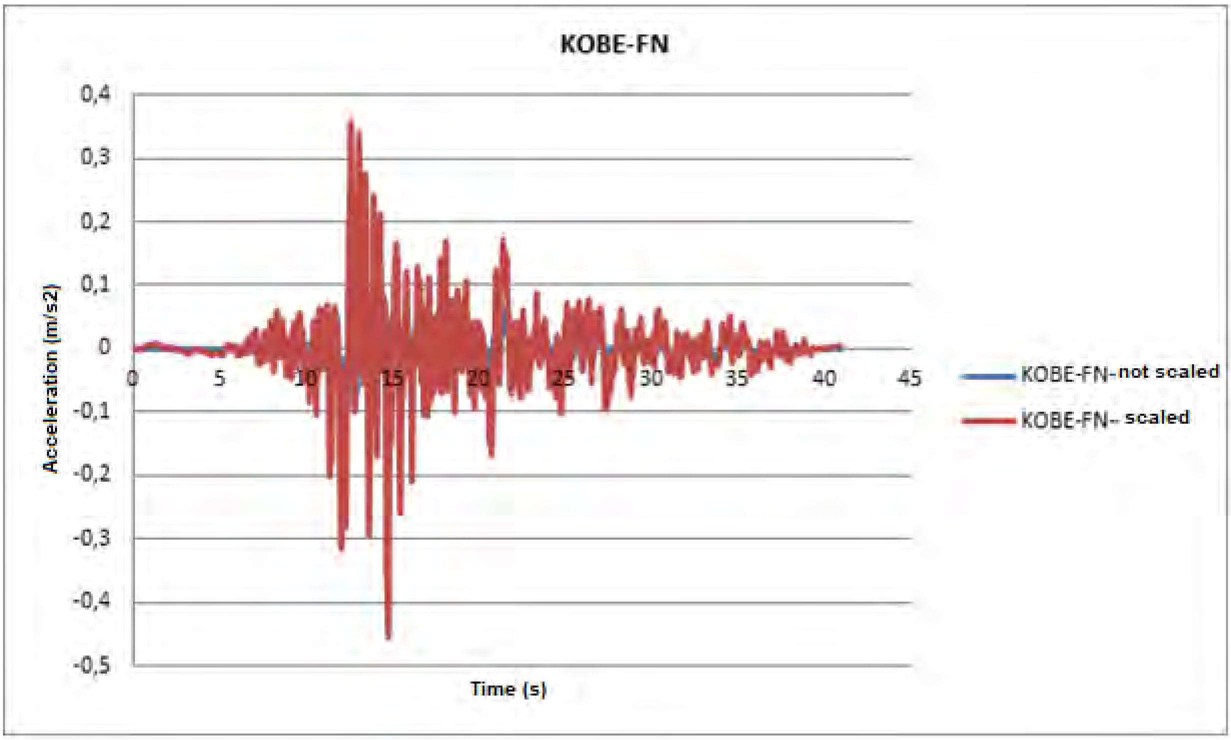


Figure 2.11 Erzincan FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



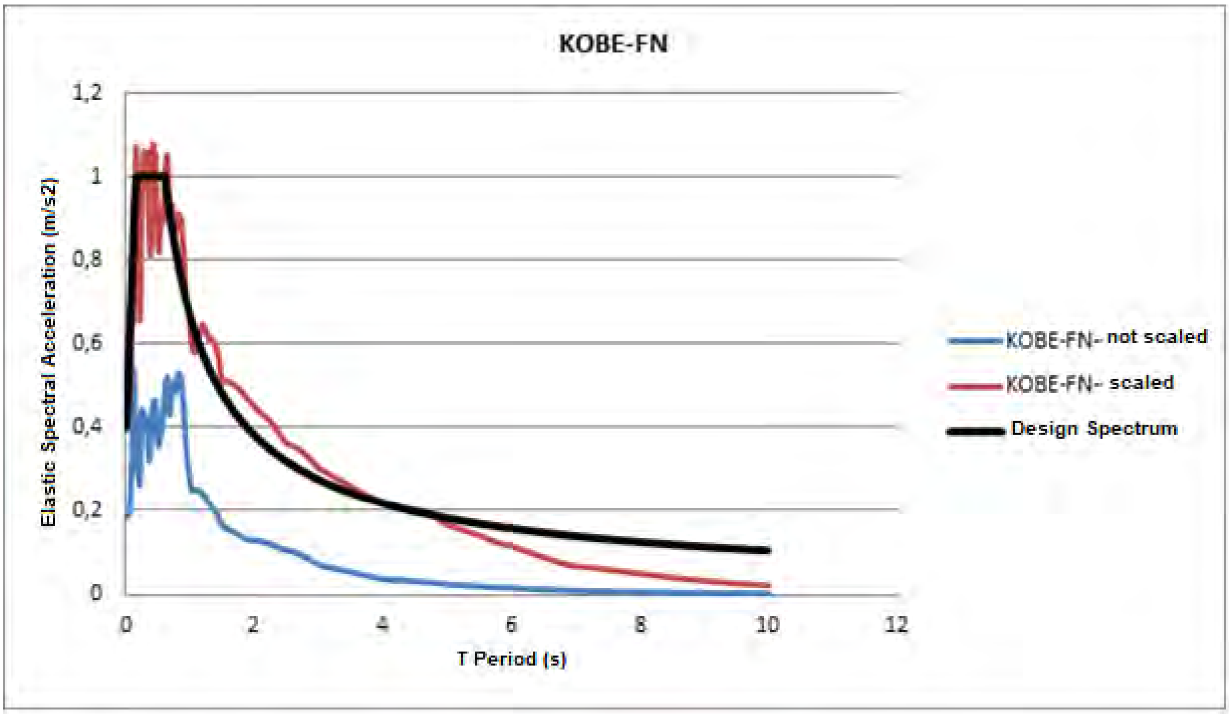
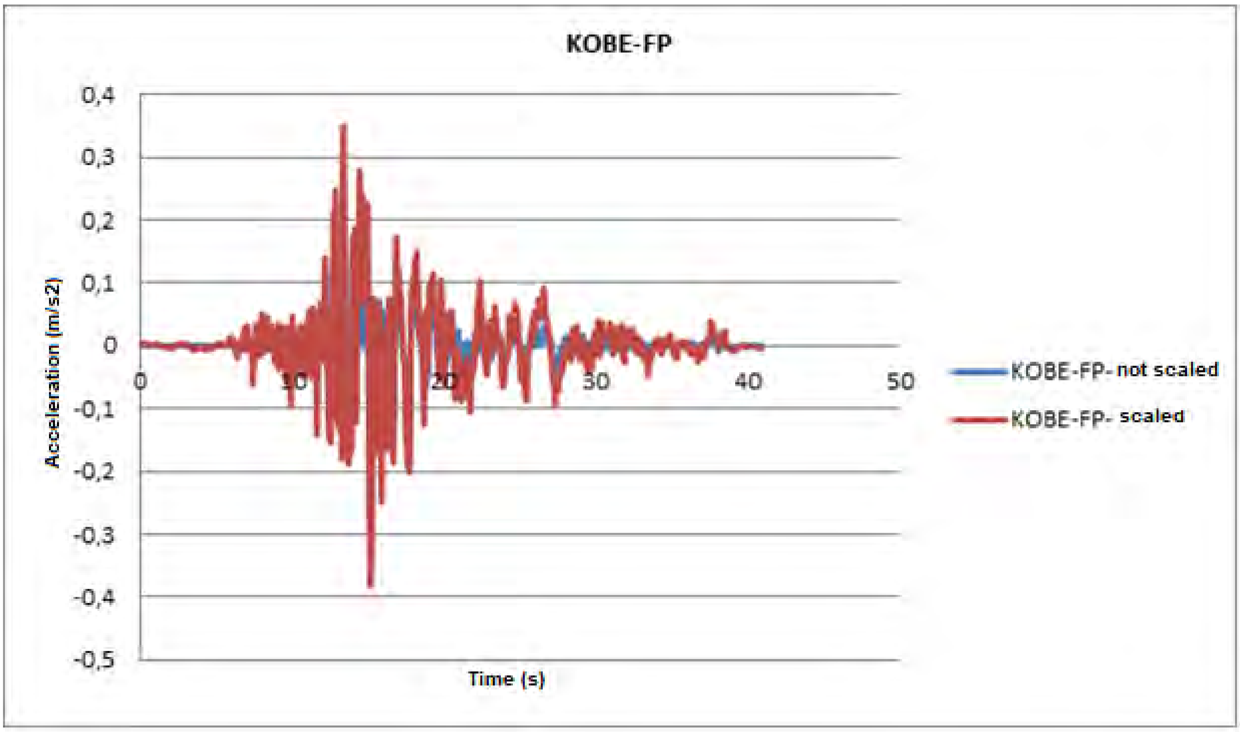


Figure 2.12 Kobe FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



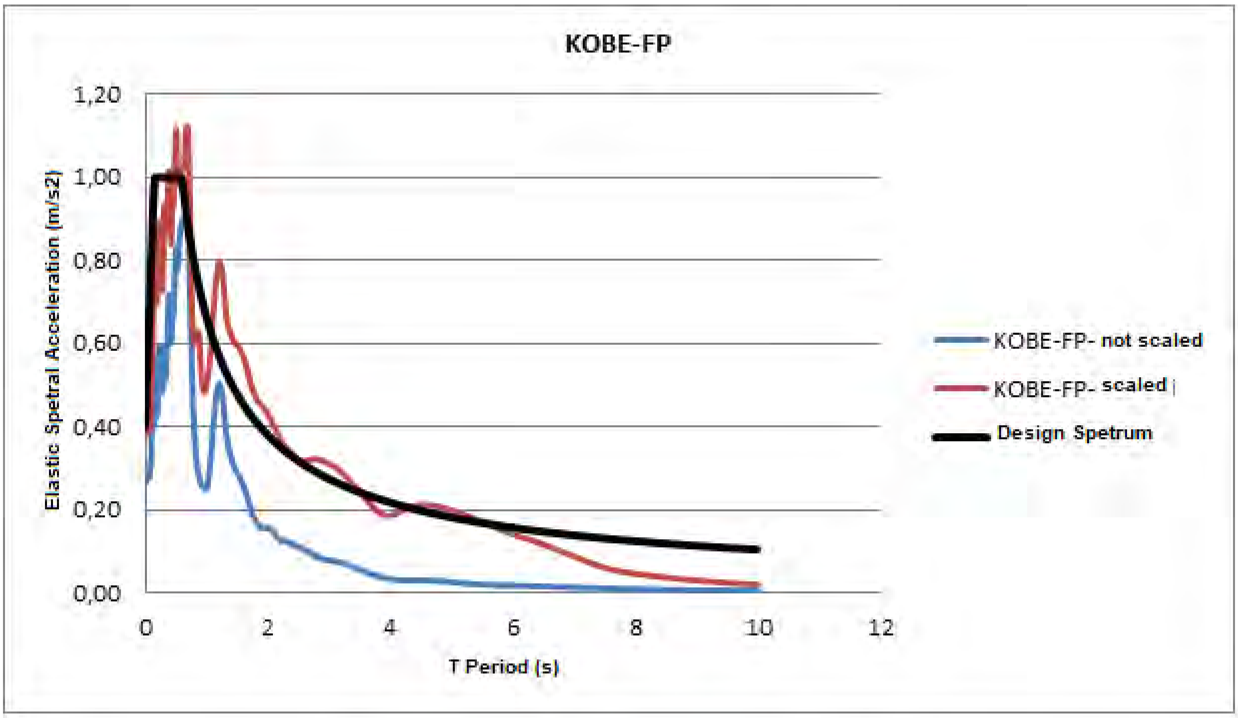
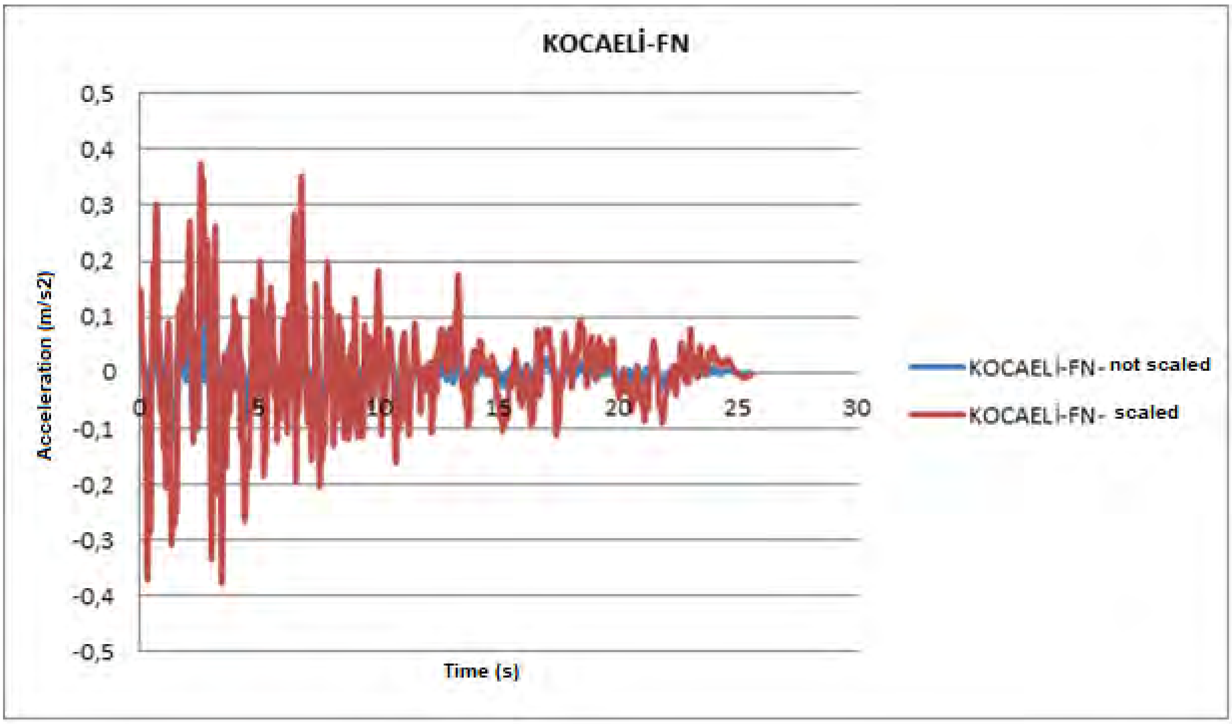


Figure 2.13 Kobe FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



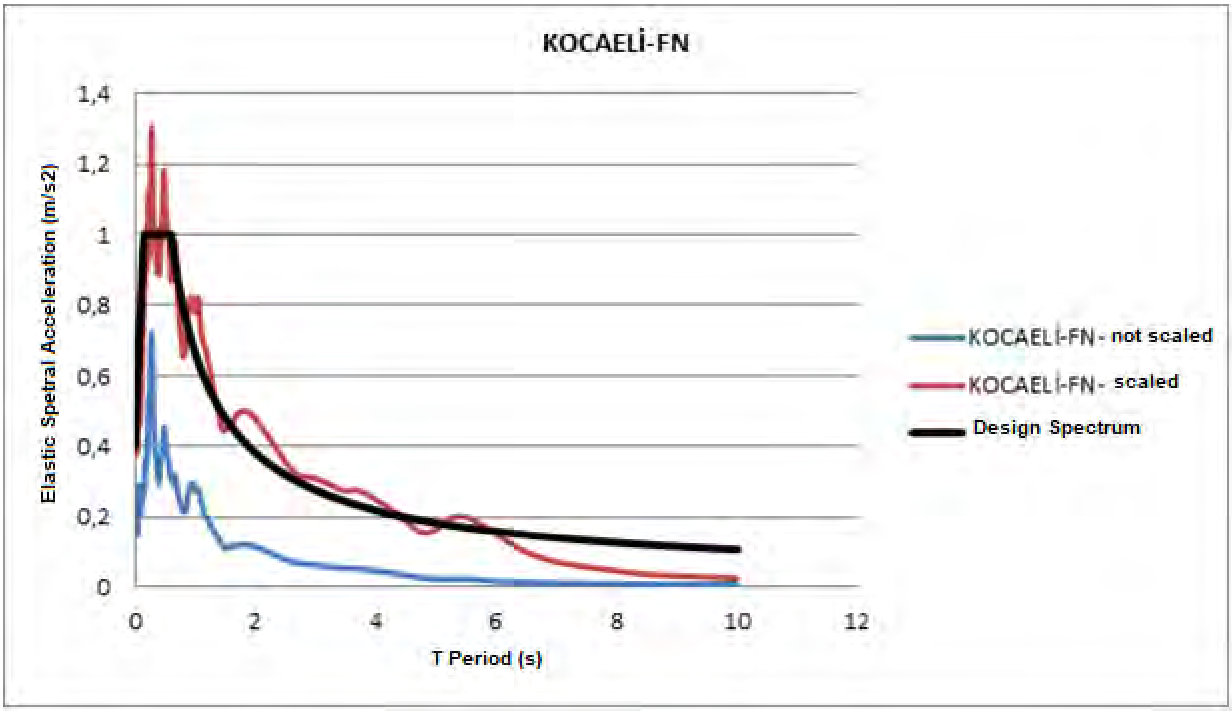
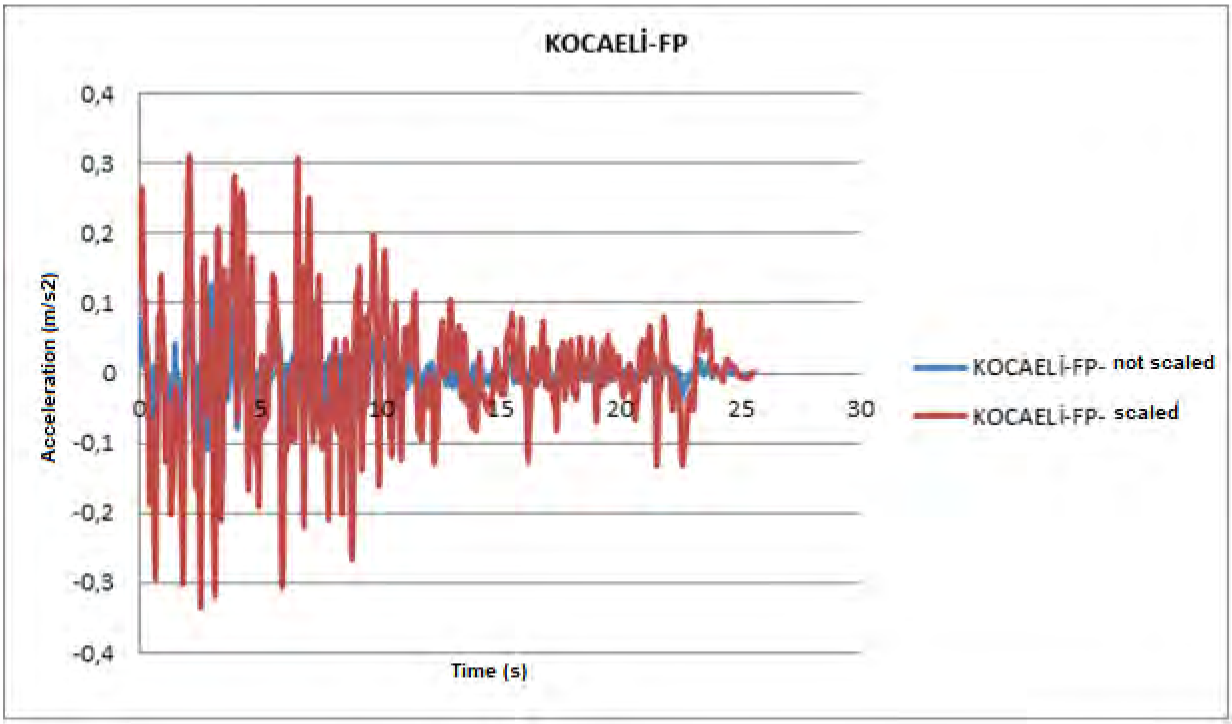


Figure 2.14 Kocaeli FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



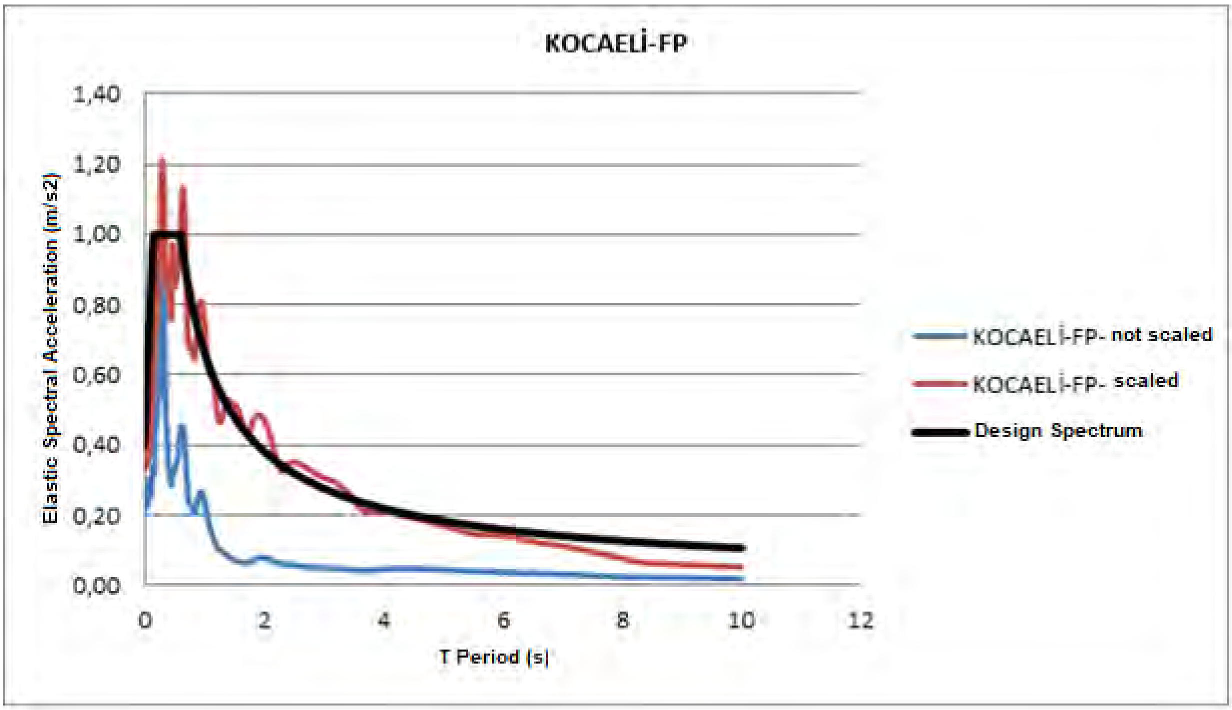
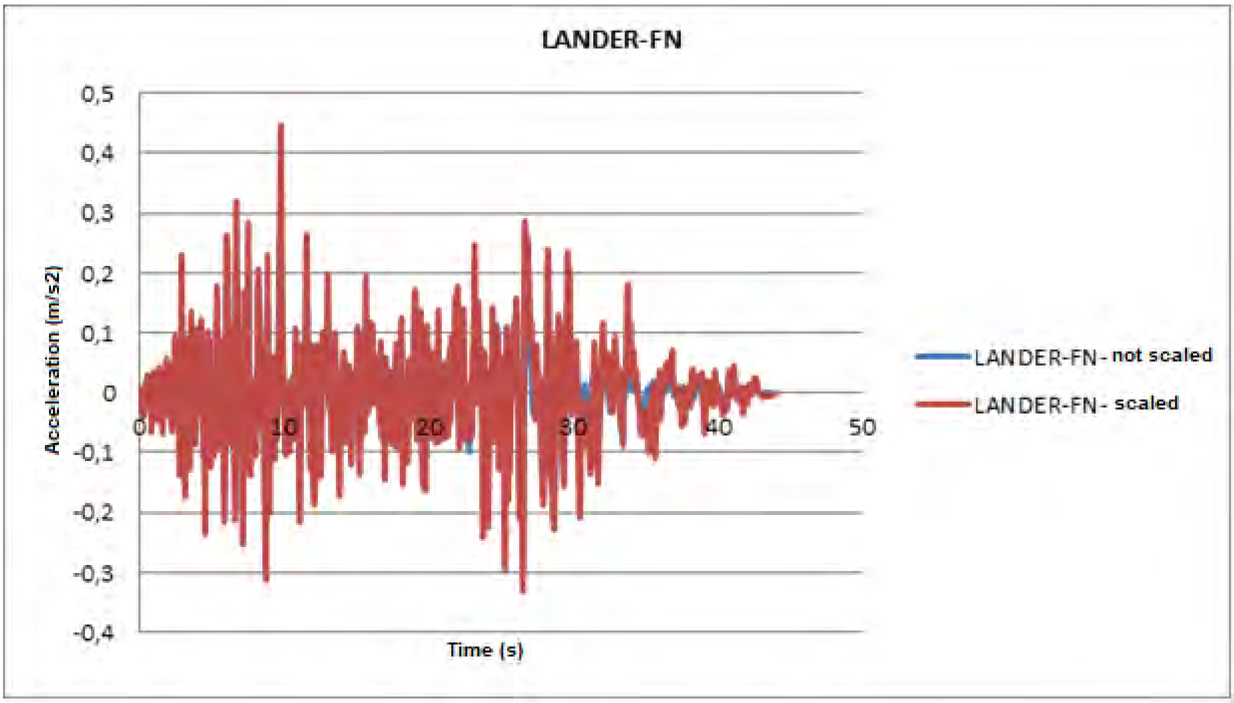


Figure 2.15 Kocaeli FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



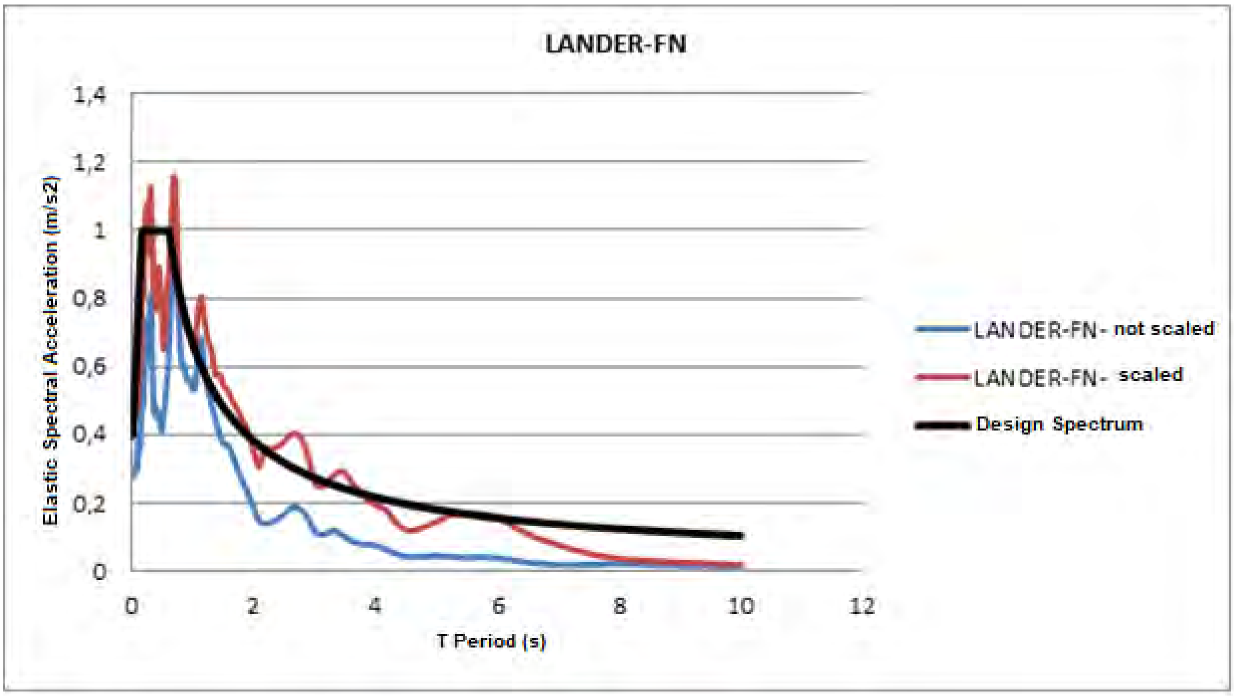
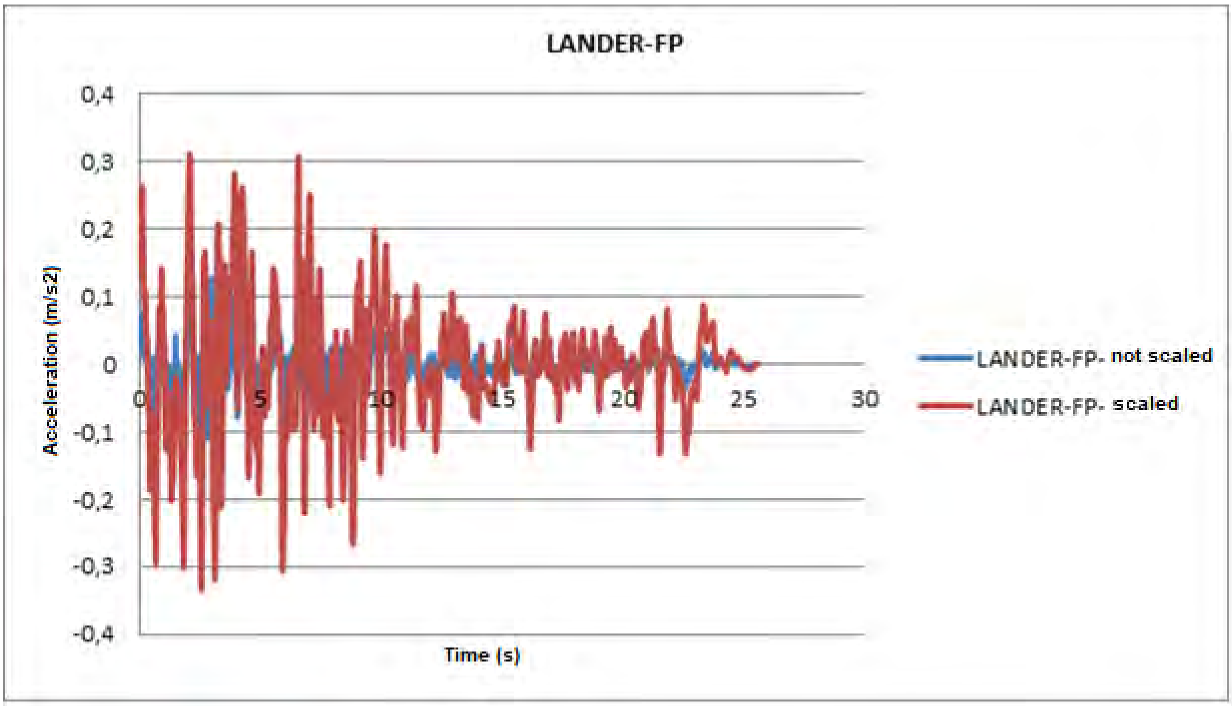


Figure 2.16 Lander FN Earthquake Acceleration Record and Spectrum Scaled-Not Scaled



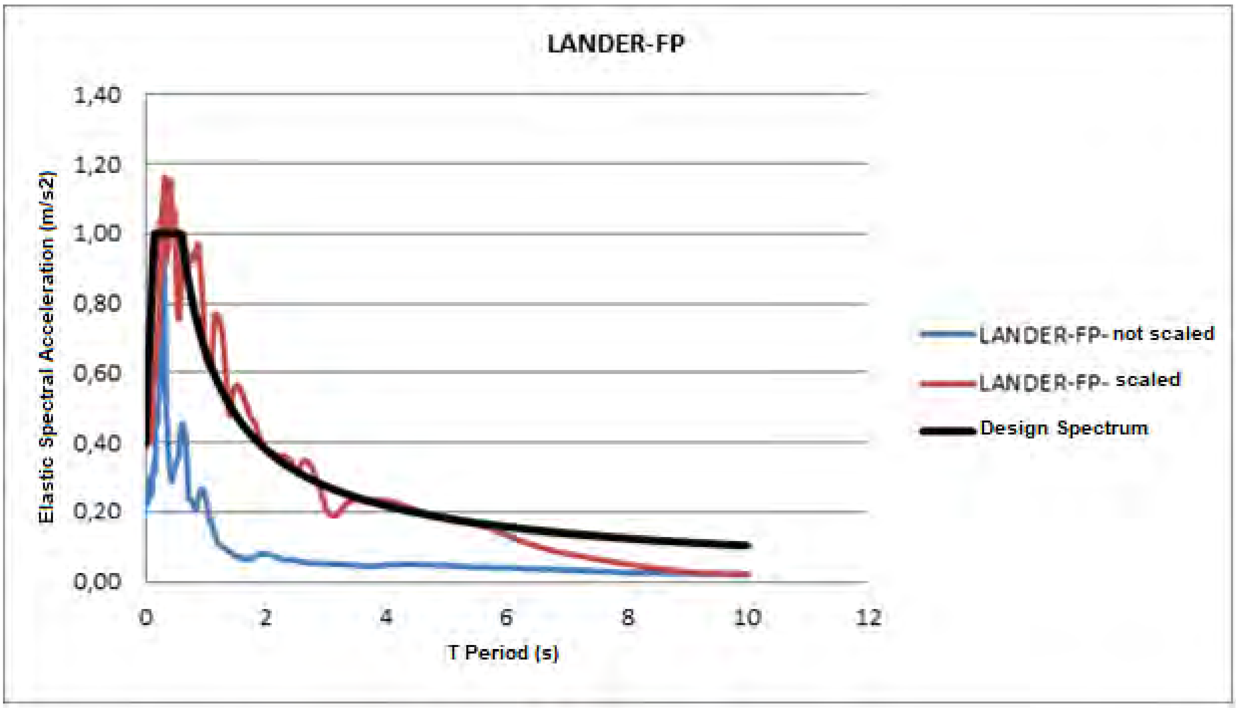


Figure 2.17 Lander FP Earthquake Acceleration Record and Spectrum Scaled-Not Scaled

3. PERFORMANCE EVALUATION STRUCTURES

Part 1 of the study included scope and purpose.. In the second section, the analysis methods used are detailed. In this section, analysis results are given for the 4-storey reinforced concrete building with shear wall and 3 storey reinforced concrete frame type school building by using the analysis methods detailed in this section.
It is tried to have the widest range of usage in selection of school building type It is paid attention to select concrete strength and structure quality to be in target building type of MaSTER FRAME® technique. ITU and Maeda studied concrete quality down to 8 MPa in experimental studies in order to determine MaSTER Disk-Ankraj® performance. However, due to the fact that it is the goal of strengthening without ever entering the building, the quality of concrete is preferred 15 MPa. Consequently, the target building type is determined as having concrete quality higher than 14 MPa and buildings that undesired to be entered. It is realized that percentage of school buildings having concrete quality higher that 14 MPa may be around 20-25 % from PROMER's archive.

3.1. Performance Evaluation of Existing 4 Storey School Building with Shear Walls.

3.1.1. Loads, material quality and earthquake parameters.

Table 3.1 Summary Information for Existing 4 Storey School Building With Shear Walls

Building Name	:	**Typical 4 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Structure Type	:	Reinforced concrete with shear walls
Storey Height, Floor Area, # of Storey	:	2.9 m 760 m2 4 storey
Total Area	:	3040 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Contribution Factor	:	0.60
Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Level Slab Loads	:	G=1.49 kN/m2, Q=2.25 kN/m2
Duvar Birim Ağırlığı	:	3.90 kN/m2
Foundation Type	:	Continous Footing
Target Performans	:	Immeditate Occupancy in the earthquake level with 10% exceedence probability in 50 years. Life Safety in the earthquake level with 2% exceedence probability in 50 years
Defined Cracked Section Rijidity Factors	:	Column and shear walls: I_{22},I_{33}=0.4 Beams: I_{33}=0.4

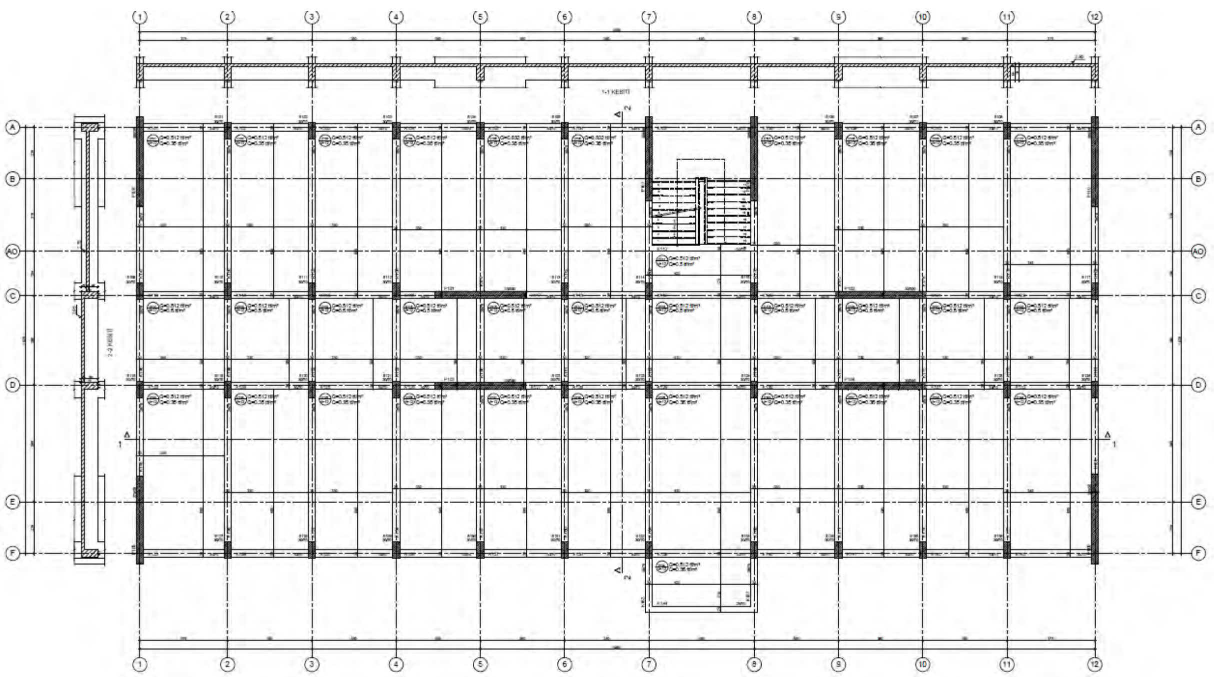


Figure 3.1 Plan view of Existing 4 Storey6 Building with Shear Walls

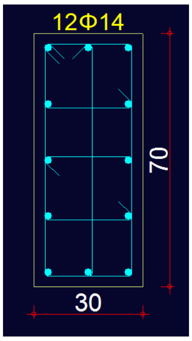


Figure 3.2 Column Reinf. Plan of 4 St. Build.

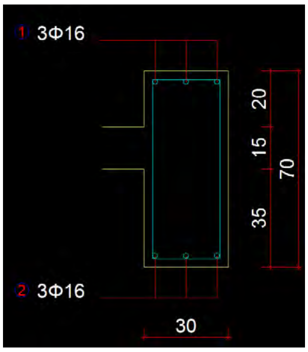


Figure 3.3 Beam Reinf. Plan of 4 St. Build.

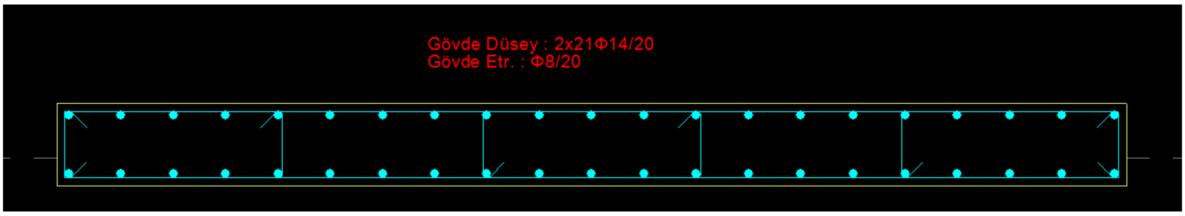


Figure 3.4 Shear Wall Reinforcement Plan of 4 Storey Building (dimensions: 380cm/30cm)

3.1.2. Modelling Structures in ETABS software

The building is modelled following the existing static plan in ETABS software using shell members for shear walls, frame members for beams and columns. Dead and live loads on the slabs have been effected on beams by converting them to equivalent distributed loads. Cracked bending section rigidities defined in table 3.1 were used In the evaluation of the nonlinear performance of the structure.
3-D ETABS model of the structure can be seen in figüre 3.3.

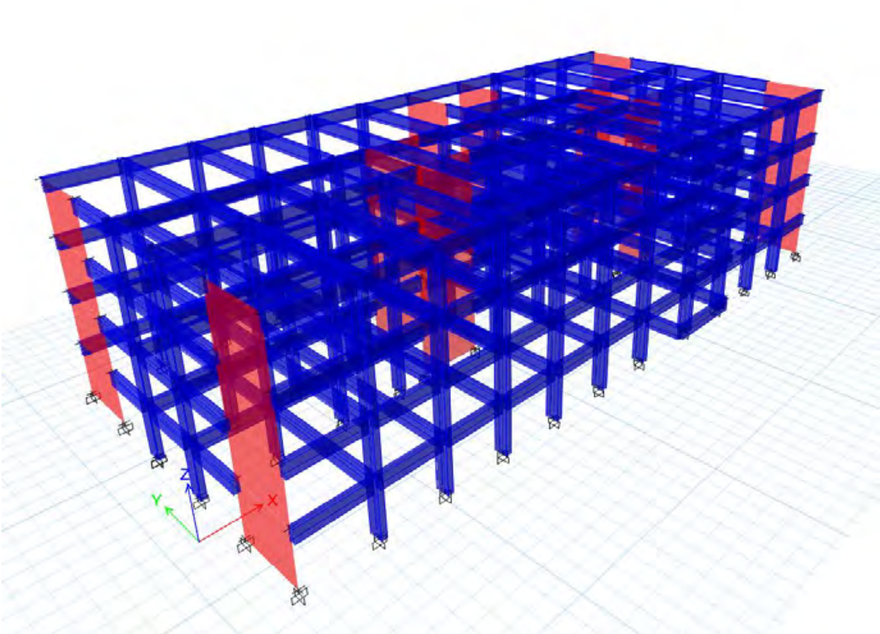


Figure 3.3 3D ETABS model of 4 storey structure with shear walls.

3.1.3. Dynamic analysis of the structure

Table 3.2 shows the modal period and mass participation ratios of the building and table 3.3 shows the storey masses used in the earthquake analysis.

Table 3.2 Modal Periods and Mass Participation Ratios

Modal Mass Participation Ratios 4 STOREY EXISTING MODEL				
Case	Mode	Period	UX	UY
		sec		
Modal	1	0.319	0.7258	1.25E-06
Modal	2	0.282	1.08E-05	0.7032
Modal	3	0.229	0.0003	0.0128
Modal	4	0.076	0.1971	0
Modal	5	0.064	7.52E-06	0.199
Modal	6	0.057	0.0012	0.0002
Modal	7	0.057	0.0006	0.0008
Modal	8	0.057	0.0001	4.21E-06
Modal	9	0.056	1.06E-05	9.9E-06
Modal	10	0.05	1.24E-05	0.0045
Modal	11	0.036	0.0524	8.02E-07
Modal	12	0.032	1.22E-06	0.0504
Modal	13	0.025	0.0106	2.11E-06
Modal	14	0.024	0	0.0091
Modal	15	0.023	3.01E-06	0.0061
Modal	16	0.018	0	2.46E-06
Modal	17	0.018	0	1.02E-05
Modal	18	0.018	4.01E-06	0.0009
Modal	19	0.018	0	0.0004
Modal	20	0.017	1.2E-05	0.0001

Tx= 0.31 s
Ty= 0.28 s

Table 3.3 4 Storey Existing Model Storey Masses used for Earthquake Analysis

Storey No	W (kN)
1	9962.501
2	10811.284
3	8175.626
4	8820.298
Total	37769.7085

3.1.4. Pushover analysis of the structure and determination of target displacement.

Calculated values at the moment the structure is pushed until 4% total drift by multiplying storey masses and related modal amplitudes are shown in figüre 3.4 and 3.5

Table 3.4 Calculation of Effective Storey Mass and Modal Amplitude for Existing 4 Storey Building with Shear Wall

1. Period X Direction 0.319 s

Storey no	W (kN)	m_i	Φ_{xin}	$m_i\Phi_{i1(x)}$	L_{xn}	$m_i\Phi_{i1}^{2(x)}$	M_n	M_{xn}	%	Γ_{x1}
1	9962.501	1015.545	0.0040	4.06218165	57.19	0.016249	1.16	2831.35	0.74	49.50
2	10811.284	1102.068	0.0110	12.1227443		0.13335				
3	8175.626	833.3972	0.0190	15.8345465		0.300856				
4	8820.298	899.1129	0.0280	25.1751619		0.704905				
Total	37769.7085	3850.123								

2. Period Y Direction 0.282 s

Storey no	W (kN)	m_i	Φ_{yin}	$m_i\Phi_{i1(y)}$	L_{yn}	$m_i\Phi_{i1}^{2(y)}$	M_n	M_{yn}	%	Γ_{y1}
1	9962.5005	1015.545	0.003	3.04663624	53.28	0.00914	1.03	2761.30	0.72	51.83
2	10811.2838	1102.068	0.01	11.0206767		0.110207				
3	8175.6264	833.3972	0.019	15.8345465		0.300856				
4	8820.2978	899.1129	0.026	23.3769361		0.6078				
Total	37769.7085	3850.123								

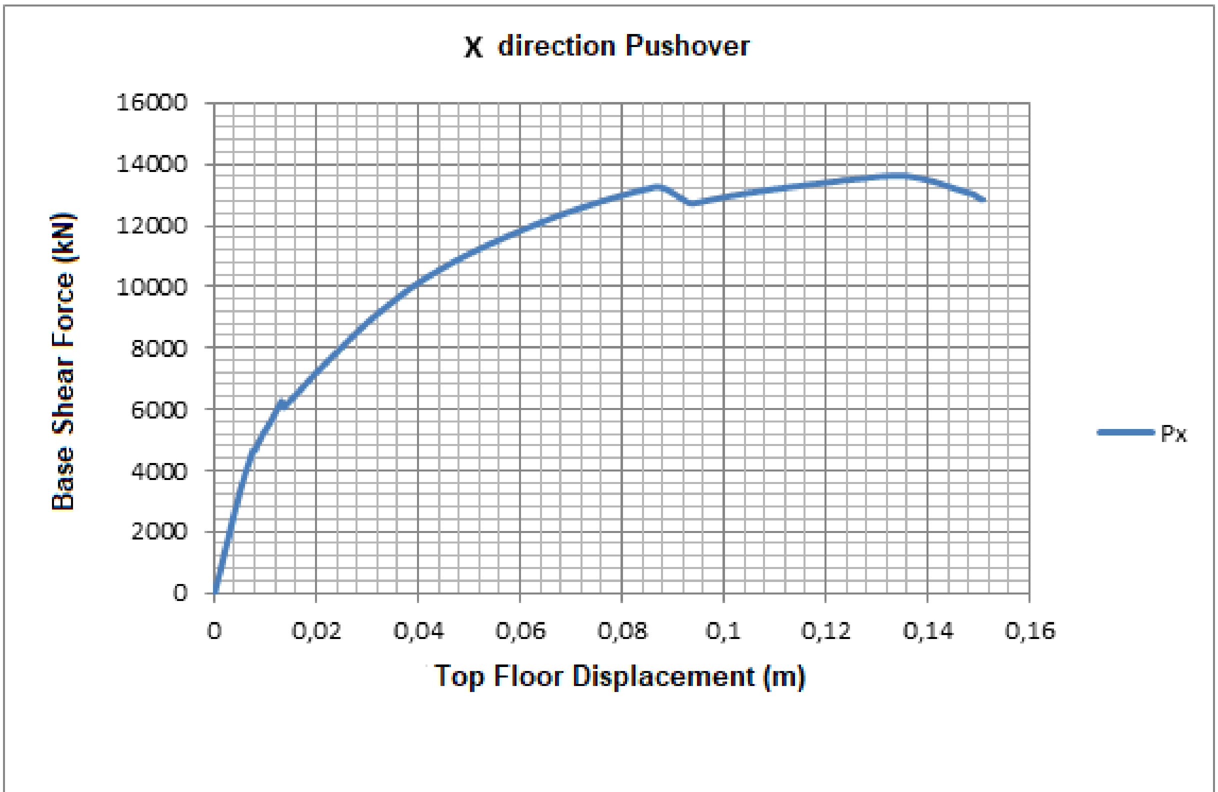


Figure 3.4 Existing 4 Storey Building Base Shear Force-Top Floor Displacement Diagram for X Dir.

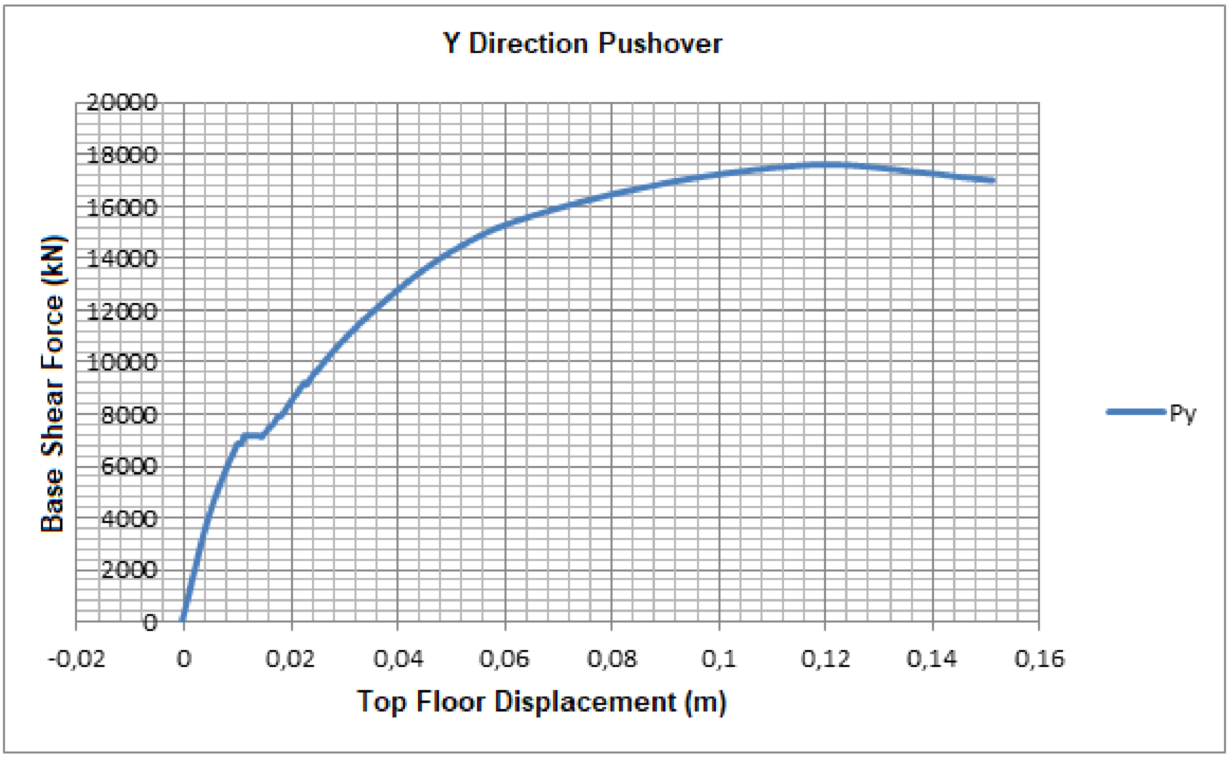


Figure 3.5 Existing 4 Storey Building Base Shear Force-Top Floor Displacement Diagram for Y Dir.

After pushover analysis have performed for both directions, target displacements are calculated as it is described in section 2.6.1.1

Table 3.5 Calculation of Modal displacement demand for Existing 4 Storey Building with Shear Wall.

									target displacement (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.319	2.5	9.81	1	0.025287	3.355292	2.92374	1.579593	0.039943	0.055
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.282	2.5	9.81	1	0.019761	4.164699	2.355512	1.648927	0.032584	0.044

3.1.5. Determination of section damage levels

Once the target displacement has been determined for both directions, the structure is pushed to the calculated target values. The aim of this step is to determine the permanent rotations in the structural elements under the applied deformation and then to calculate the unit deformation values of the concrete and steel materials in the elements due to these rotations. Calculated deformations are compared with the section damage zones defined in section 2.6.1.2 and material deformation limits in order to determine member damage zone.
In the following section, the damage status of the beams, columns and curtains will be calculated at their sections.

BEAMS
When determining the damage zone in the beams, first the total rotational demand of the structure will be calculated as described in Section 2.6.1.1. then, member sectional unit deformations are calculated under total deformation of the building.
The table below shows the level of damage resulting from the X-direction pushover analysis of the 3 rd floor beams from the existing 4 storey structural elements. Damage status of other members are shown in related sections.

BEAM DAMAGE STATUS
TYPICAL 4 STOREY SCHOOL BUILDING WITH SHEAR WALLS

KAT	KIRIS		θ_p	L_p	ϕ_p	ϕ_y	ϕ_t	εs	εc	HASAR BÖLGELERİ
3.KAT	B21	SAĞ UÇ	0.00945	0.35	0.02699	0.00614	0.03313	0.01118	0.01211	GV
3.KAT	B112	SAĞ UÇ	0.01381	0.35	0.03946	0.00614	0.0456	0.01395	0.01523	GÇ
3.KAT	B114	SAĞ UÇ	0.01366	0.35	0.03901	0.00614	0.04515	0.01386	0.01513	GÇ

COLUMNS AND SHEAR WALLS

For column sections, moment-curvature relationship is obtained by using material model which takes into account the effect of wrapping of concrete.. Then, by defining the allowable deformation limits according to the performance levels specified in the regulation, the normal force total curvature diagrams are obtained in the column sections corresponding to these limits. Normal force-total curvature demand values found in the analysis are placed on this diagram and the damage zone of the section is determined. 4 and 3 storey building columns (30x70) for X and Y direction capacity graph is shown as an example in figure 3.5.a. Performance analysis of the other columns in both directions is shown in the relevant sections

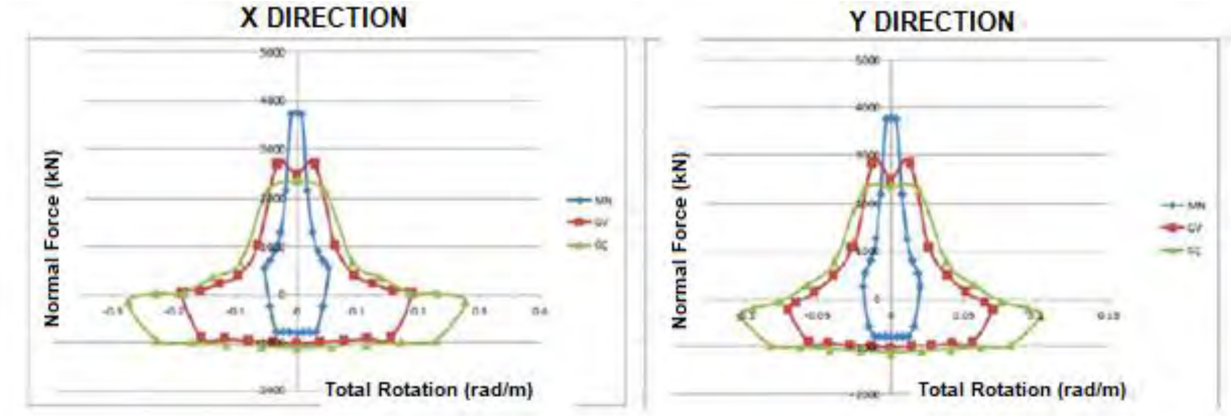


Figure 3.5.a Sample Capacity Diagram for X and Y direction of Existing Building.

3.1.5.1. Fixed first mode pushover analysis column results for 4 storey building with shear walls.

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis of the existing 4 storey structure with shear walls are given in **ATT-A-I-1**.
Axial load-curvature curves in Figure 3.6 and Figure 3.7 is plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that there are members in minimum damage and life safety damage zones. All columns in Y direction are in minimum damage level.

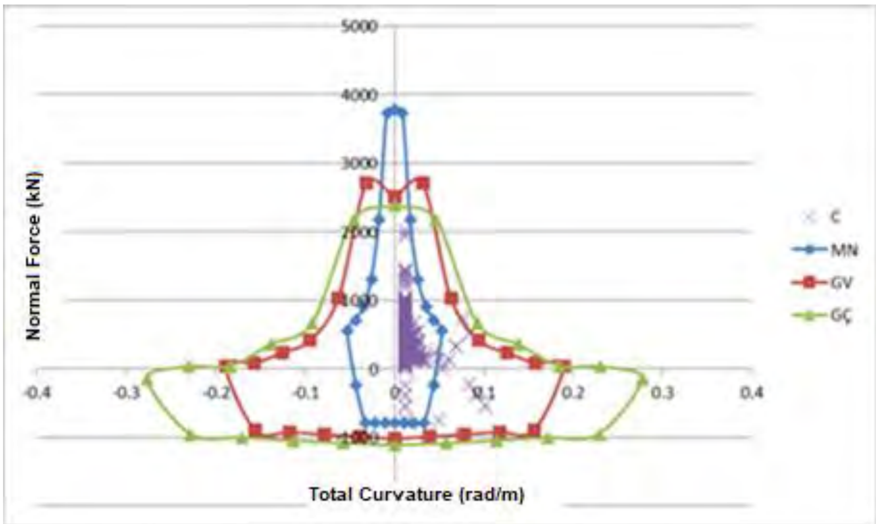


Figure 3.6 X Direction Pushover Analysis Existing Column Assessment Results

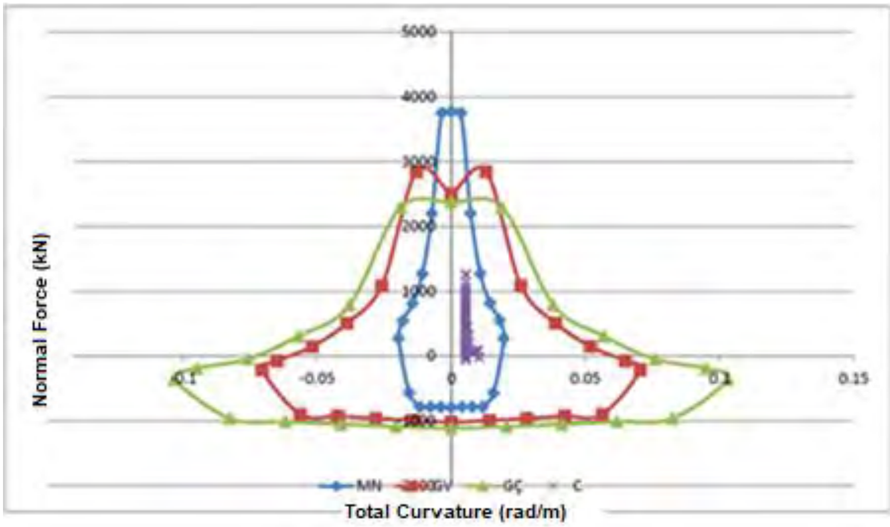


Figure 3.7 Y Direction Pushover Analysis Existing Column Asessment Results

3.1.5.2. Fixed first mode pushover analysis shear wall results for 4 storey building with shear walls

The tables of the evaluation of the shear walls prepared according to the results of fixed first mode pushover analysis of the existing 4 storey structure with shear walls are given in **ATT-A-I-2**.
Axial load-curvature curves in Figure 3.8 and Figure 3.9 is plotted for each damage limit, in order to summarize and visualize table data. When the shear wall curvatures obtained as a result of analysis were placed in the diagrams, it is seen that there are members in minimum damage and life safety damage zones. There are shear Wall members over minimum damage level although they are close to the limits for Y direction.

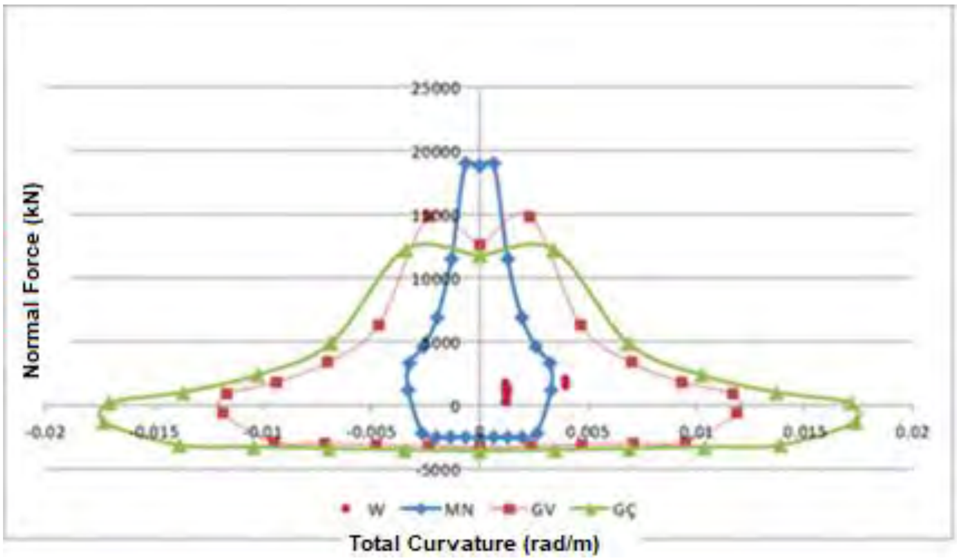


Figure 3.8 X Direction Pushover Existing Shear Wall Assessment Results

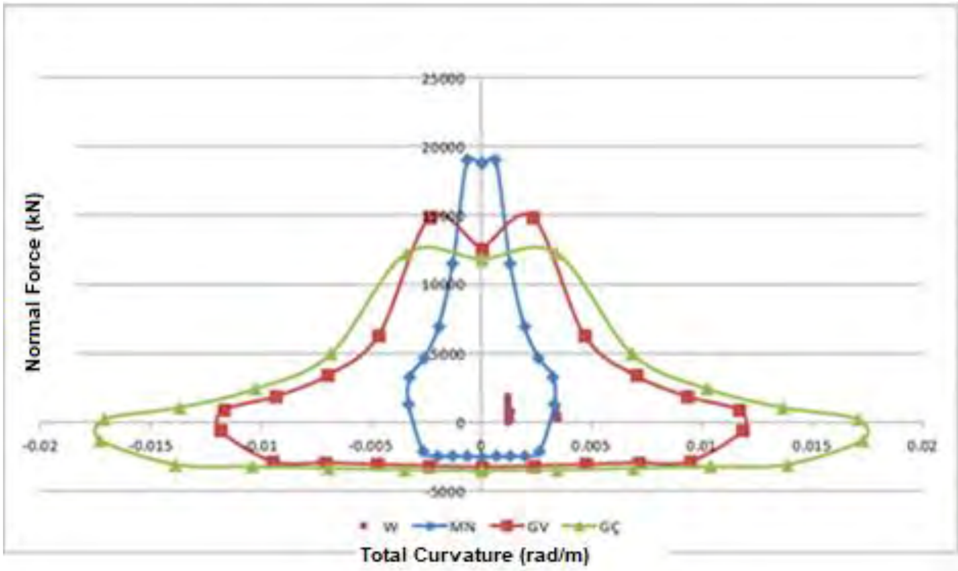


Figure 3.9 Y Direction Pushover Existing Shear Wall Assessment Results

3.1.5.3. Fixed first mode pushover analysis beam results for 4 storey building with shear walls

The tables of the evaluation of the beams prepared according to the results of fixed first mode pushover analysis of the existing 4 storey structure with shear walls are given in **ATT-A-I-3**.
It is seen in the tablet hat 6 pcs. Beams are in significant damage zone.

Summary table of performance evaluation with fixed first mode pushover analysis for existing 4 storey building with shear walls

All results given up to this section as diagrams and tables are summarized in Table 3.7.
All columns in the X direction are in the minimum damage zone. 6 of the beams are in the significant damage zone. 4 of the shear walls are in significant damage zone on the ground floor.
All columns in the Y direction are in the minimum damage zone, 8 beams are in the significant damage zone and 6 of the shear walls is significant damage zone.
As a result, Because in both X and Y direction, the shear walls have been in significant damage zone, the minimum damage under the effect of design earthquake load effect which is required criteria according to the DBYBHY 2007does not satisfied. It needs strengthening.

Table 3.7 Summary table of performance evaluation with fixed first mode pushover analysis for existing 4 storey building with shear walls

EXISTING 4 STOREY BUILDING WITH SHEAR WALL / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	32/36	4/36	--	36/44	6/44	2/44	4/4	--	--
2nd storey	33/36	3/36	--	36/44	6/44	2/44	4/4	--	--
1st storey	34/36	2/36	--	36/44	6/44	2/44	4/4	---	--
Ground Floor	34/36	2/36	--	36/44	6/44	2/44	--	4/4	--

EXISTING 4 STOREY BUILDING WITH SHEAR WALL / PUSH Y									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	32/38	6/38	--	6/6	--	--
2nd storey	36/36	--	--	29/38	8/38	--	6/6	--	--
1st storey	36/36	--	--	30/38	8/38	--	6/6	--	--
Ground Floor	36/36	--	--	32/38	6/38	--	--	6/6	--

3.2. Performance Evaluation with Fixed First Mode Pushover Analysis of 4 Storey School Building with Shear Walls and Strengthened using MaSTER FRAME®

3.2.1. Loads, material quality and earthquake parameters

Tablo 3.8 Summary Information of 4 Storey School Building With Shear Walls and retrofitted using MaSTER FRAME®

Building Name	:	**Typical 4 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Structure Type	:	Reinforced concrete with shear walls
Storey Height, Floor Area, # of Storey	:	2.9 m 760 m2 4 storey
Total Area	:	3040 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
MaSTER FRAME® Concrete Quality, Reinforcement Type	:	30 MPa – ST III
MaSTER FRAME® members-existing members anchorage type	:	MaSTER Disk-Ankraj®
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Contribution Factor	:	0.60
Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Level Slab Loads	:	G=1.49 kN/m2, Q=2.25 kN/m2
Partition Wall Unit Weight	:	3.90 kN/m2
Foundation Type	:	Continous Footing
Target Performans	:	Immeditate Occupancy in the earthquake level with 10% exceedence probability in 50 years. Life Safety in the earthquake level with 2% exceedence probability in 50 years
Defined Cracked Section Rijidity Factors	:	Column and shear walls: I22,I33=0.4 Beams: I33=0.4

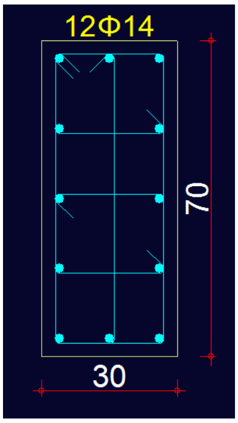


Figure 3.10 Column Reinf. Plan of 4 St. Build

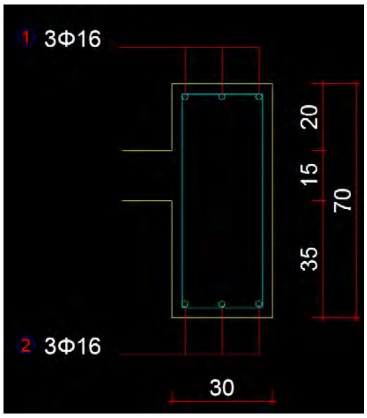


Figure 3.11 Beam Reinf. Plan of 4 St. Build.

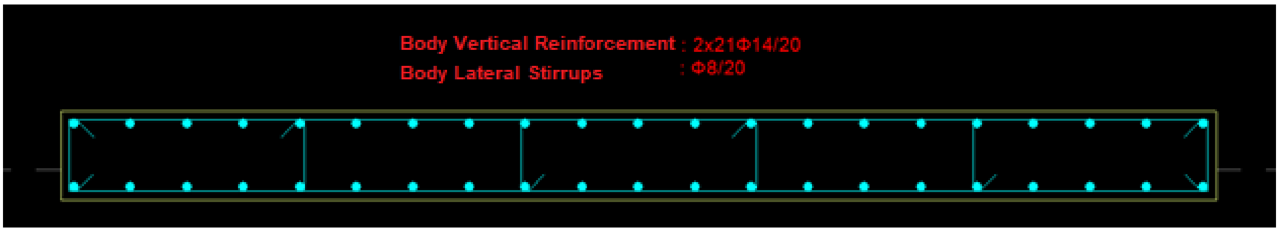


Figure 3.12 Shear Wall Reinforcement Plan of 4 Storey Building (dimensions: 380cm/30cm)

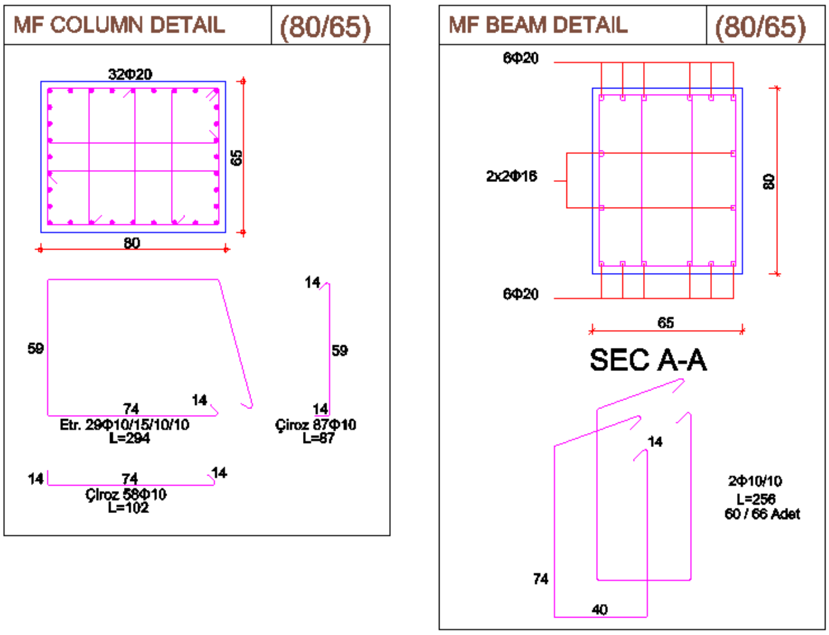


Figure 3.13 MaSTER FRAME® Column and Beam Dimensions and Reinforcement Plan

3.2.2. Modelling Structures in ETABS software

The building is modelled following the existing static plan in ETABS software using shell members for shear walls, frame members for beams and columns. Dead and live loads on the slabs have been effected on beams by converting them to equivalent distributed loads. Cracked bending section rigidities defined in table 3.8 were used In the evaluation of the nonlinear performance of the structure.
3-D ETABS model of the structure can be seen in figüre 3.14.

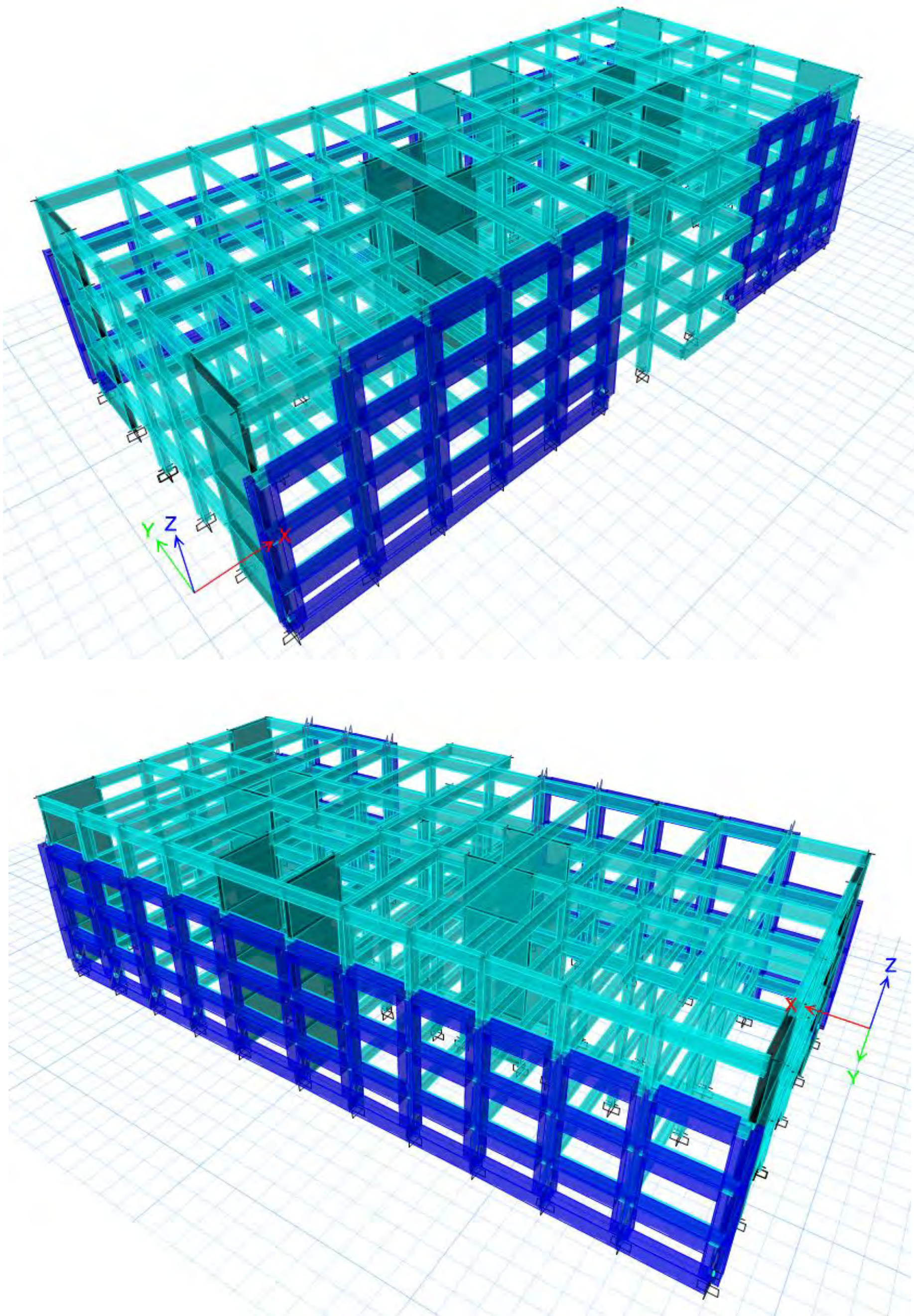


Figure 3.14 3D ETABS model of 4 storey structure and retrofitted using MaSTER FRAME®

3.2.3. Dynamic analysis of the structure

Table 3.9 shows the modal period and mass participation ratios of the building and table 3.10 shows the storey masses used in the earthquake analysis.

Tablo 3.9 Modal Periods and Mass Participation Ratios of 4 Storey Building With Shear Walls and Strengthened using MaSTER FRAME®

Modal Mass Participation Ratios 4 STOREY MODEL WİTH MASTERFRAME(c)				
Case	Mode	Period	UX	UY
		sec		
Modal	1	0.283	0.0003	0.7083
Modal	2	0.271	0.7374	0.0004
Modal	3	0.214	0.0014	0.007
Modal	4	0.076	0.1927	1.86E-05
Modal	5	0.066	1.62E-05	0.2035
Modal	6	0.057	0.001	0.0016
Modal	7	0.057	0.0004	1.28E-06
Modal	8	0.057	0.0001	0
Modal	9	0.056	0	8.24E-06
Modal	10	0.053	0.0003	0.0047
Modal	11	0.038	0.0484	4.32E-05
Modal	12	0.035	0.0001	0.0501
Modal	13	0.028	0.0001	0.0023
Modal	14	0.028	1.79E-05	0.0002
Modal	15	0.026	0.0053	0.0001
Modal	16	0.025	4.7E-05	0.0067
Modal	17	0.025	1.23E-05	0.0001
Modal	18	0.023	0.0003	2.46E-05
Modal	19	0.023	3.65E-05	5.59E-06
Modal	20	0.022	0	0.0001

Tx=0.27 s
Ty=0.28 s

Tablo 3.10 4 Storey Building Model Retrofitted Using MaSTER FRAME® Storey Masses used for Earthquake Analysis

	W (kN)
1	12185.062
2	12341.499
3	9490.749
4	9522.043
Total	43539.3538

3.2.4. Pushover analysis of the structure and determination of target displacement

Calculated values at the moment the structure is pushed until 4% total drift by multiplying storey masses and related modal amplitudes are shown in figüre 3.15 and 3.16.

Table 3.11 Calculation of Effective Storey Mass and Modal Amplitude for 4 Storey Building with Shear Wall and retrofitted using MaSTER FRAME®

2. Period X direction 0.275 s

Storey No	W (kN)	m_i	$\Phi_{i1(x)}$	$m_i\Phi_{i1(x)}$	L_{xn}	$m_i\Phi_{i1}^{2(x)}$	M_n	M_{xn}	Oran	Γ_{x1}
1	12185.062	1242.106	0.0040	4.96842499	61.46	0.019874	1.14	3308.27	0.75	53.83
2	12341.499	1258.053	0.0110	13.8385822		0.152224				
3	9490.749	967.4566	0.0180	17.4142185		0.313456				
4	9522.043	970.6466	0.0260	25.2368117		0.656157				
Total	43539.3538	4438.262								

1. Period Y direction 0.285 s

Storey No	W (kN)	m_i	$\Phi_{i1(y)}$	$m_i\Phi_{i1(y)}$	L_{yn}	$m_i\Phi_{i1}^{2(y)}$	M_n	M_{yn}	Oran	Γ_{y1}
1	12185.0623	1242.106	0.004	4.96842499	60.20	0.019874	1.12	3249.41	0.73	53.98
2	12341.4992	1258.053	0.01	12.5805293		0.125805				
3	9490.7491	967.4566	0.018	17.4142185		0.313456				
4	9522.0432	970.6466	0.026	25.2368117		0.656157				
Total	43539.3538	4438.262								

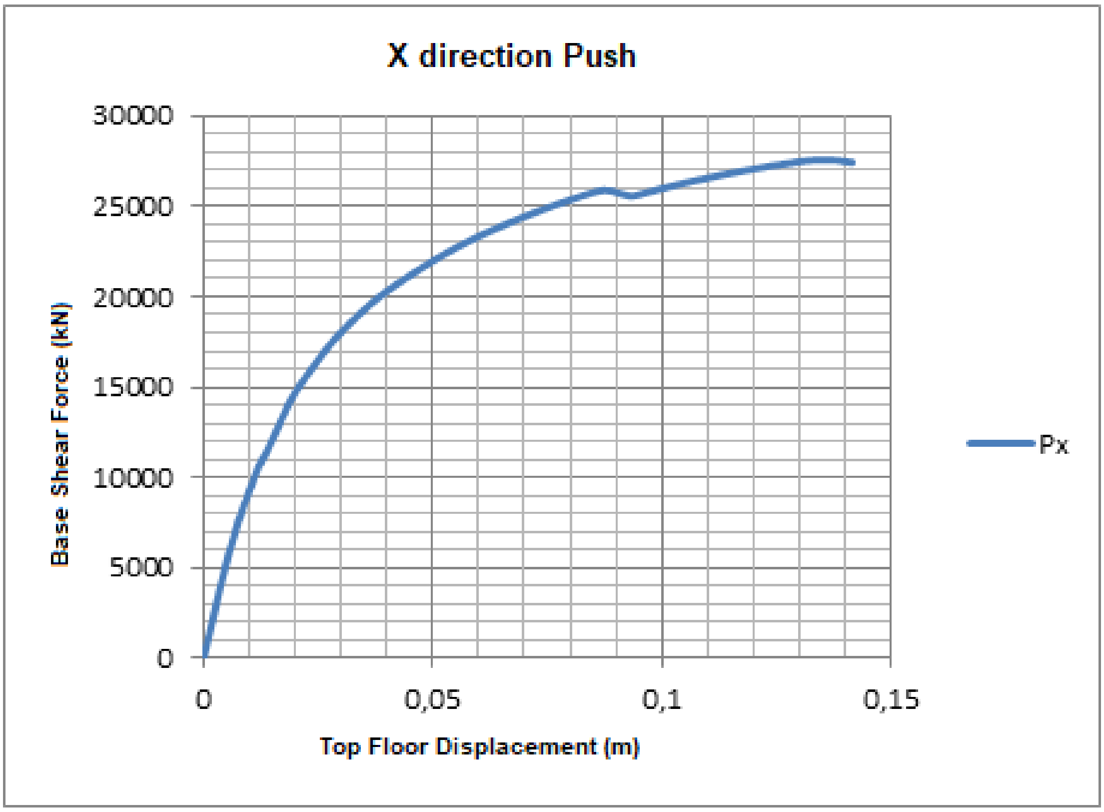


Figure 3.15 4 Storey Building Retrofitted using MaSTER FRAME® Base Shear Force-Top Floor Displacement Diagram for X Dir.

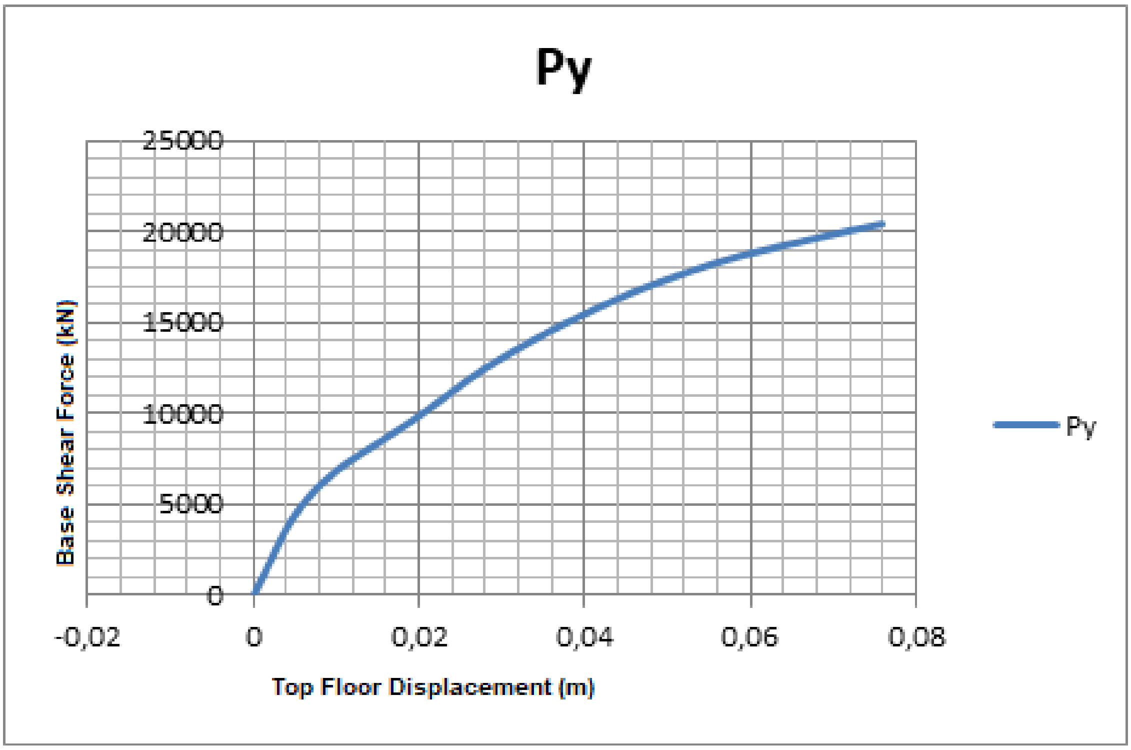


Figure 3.16 4 Storey Building Retrofitted Using MaSTER FRAME® Base Shear Force-Top Floor Displacement Diagram for Y Dir.

Comparison of Pushover Diagrams for Retrofitted an Not Retrofitted models

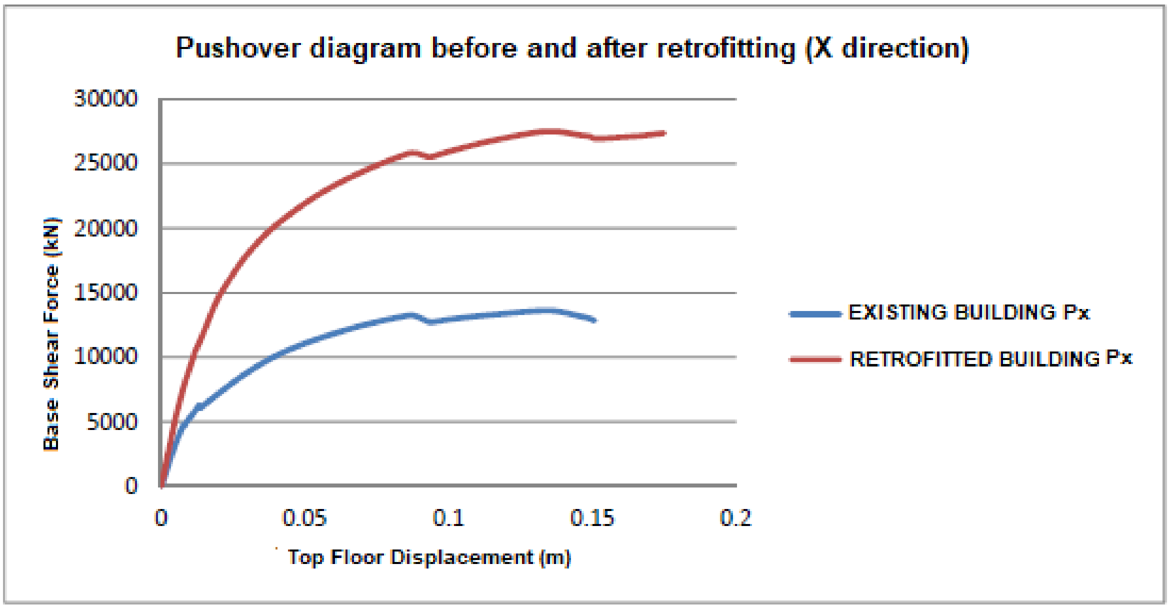


Figure 3.16a Pushover Diagrams Before and After Retrofitting (X Direction)

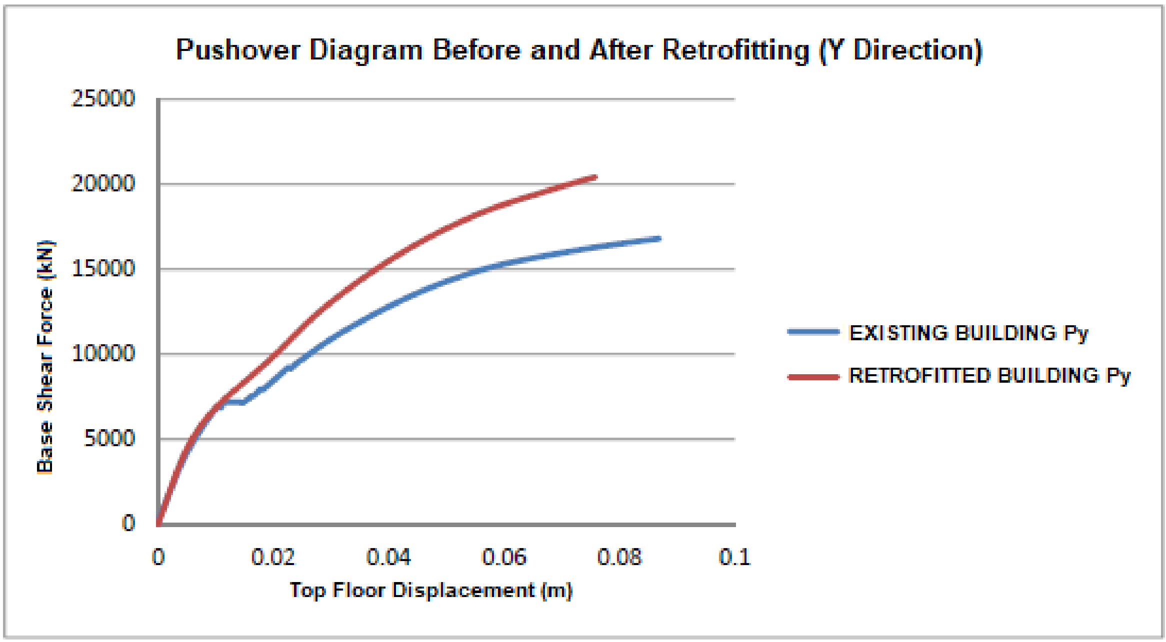


Figure 3.16b Pushover Diagrams Before and After Retrofitting (Y Direction)

After pushover analysis have performed for both directions, target displacements are calculated as it is described in section 2.6.1.1

Table 3.12 Calculation of Modal displacement demand for 4 Storey Building with Shear Wall and retrofitted using MaSTER FRAME® (for earthquake level with exceedence probability of 10 % in 50 years)

									Target Displacement (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.271	2.5	9.81	1	0.018249	6.649998	1.475188	1.391061	0.025386	0.036
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.283	2.5	9.81	1	0.019901	2.92361	3.355441	1.786313	0.03555	0.050

Table 3.12b Calculation of Modal displacement demand for 4 Storey Building with Shear Wall and retrofitted using MaSTER FRAME® (for earthquake level with exceedence probability of 2 % in 50 years)

									hedef deplasman (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.271	2.5	14.715	1.5	0.027374	6.649998	2.212782	1.665382	0.045588	0.064
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.283	2.5	14.715	1.5	0.029852	2.92361	5.033161	1.897589	0.056647	0.079

3.2.4.1. Fixed first mode pushover analysis column results for 4 storey building with shear walls and retrofitted using MaSTER FRAME®

A) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 10 % IN 50 YEARS (DESIGN EARTHQUAKE)

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-II-1**.
Axial load-curvature curves in Figure 3.17 and Figure 3.18 plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all columns in X and Y direction are in minimum damage level.

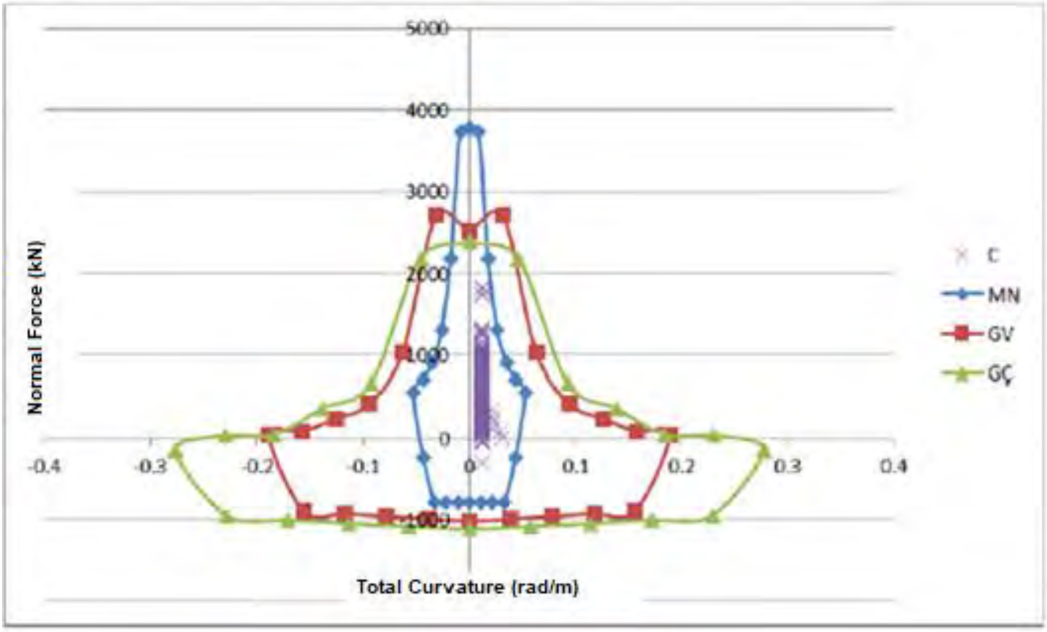


Figure 3.17a X Direction Pushover Analysis Column Assessment Results(Retrofitted Building-Existing Columns-Design Earthquake)

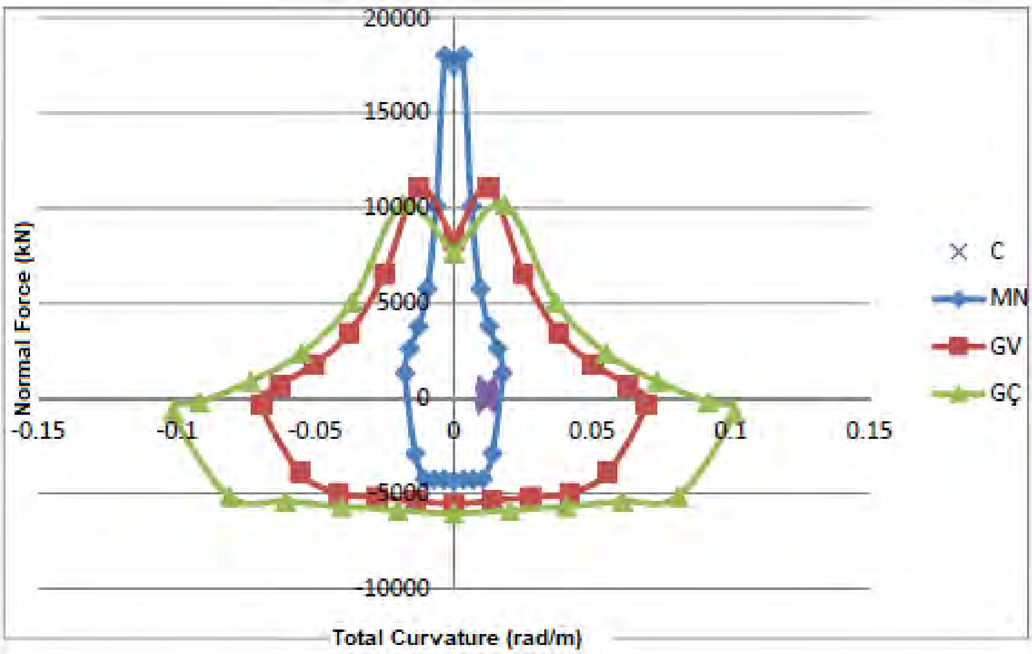


Figure 3.17b X Direction Pushover Analysis Column Assessment Results(Retrofitted Building-MaSTER FRAME® Columns-Design Earthquake)

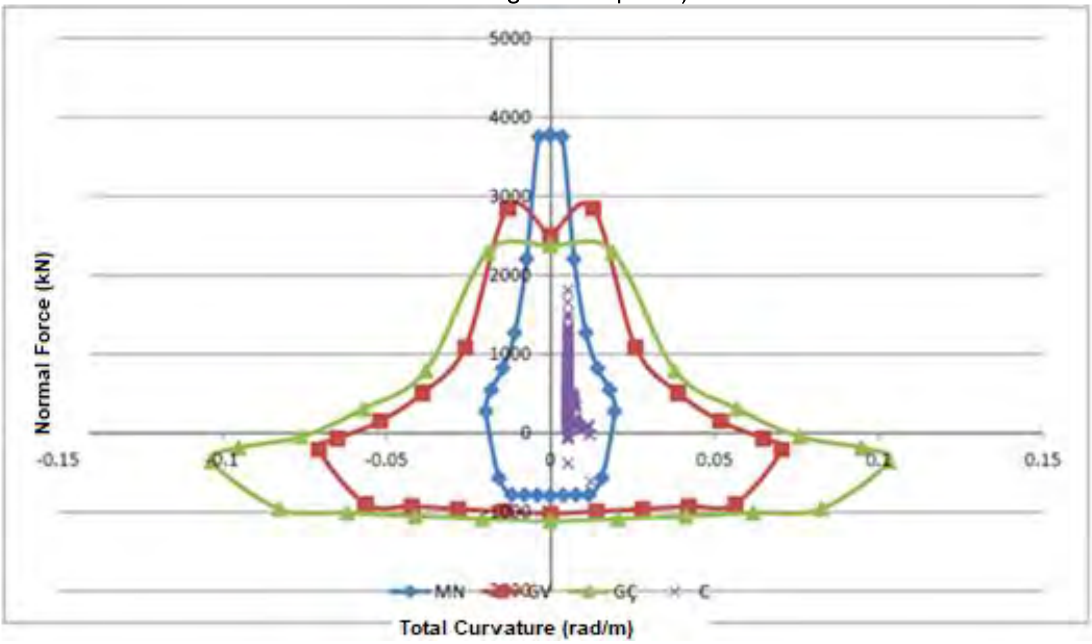


Figure 3.18a Y Direction Pushover Analysis Column Assessment Results(Retrofitted Building-Existing Columns-Design Earthquake)

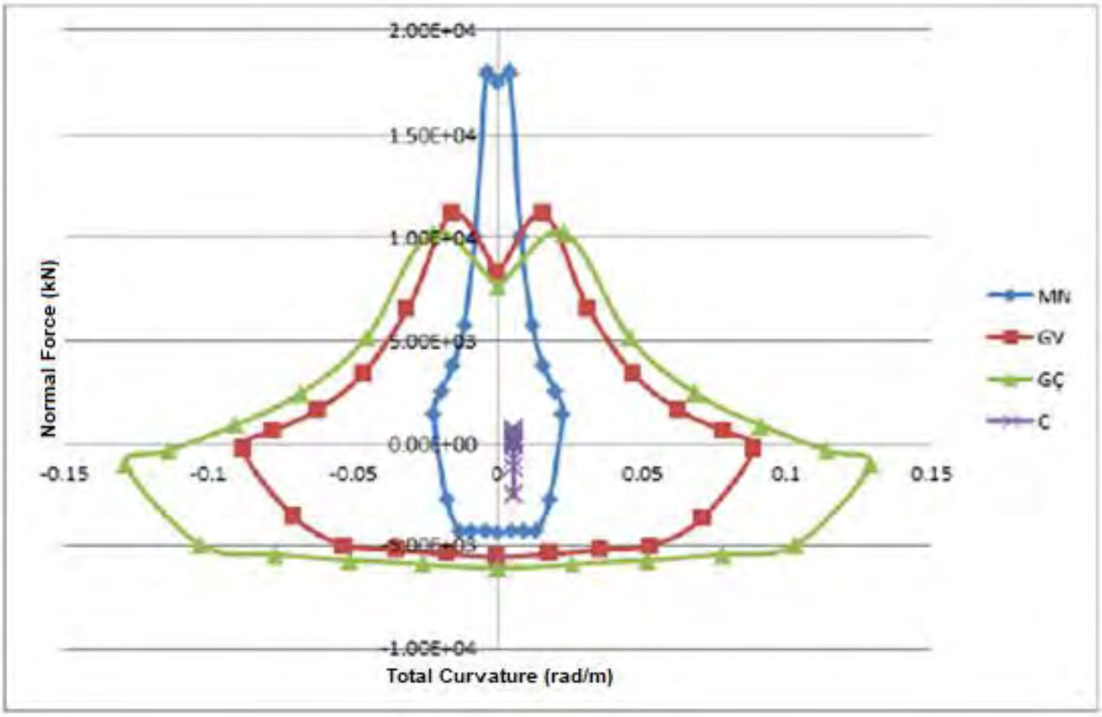


Figure 3.18b Y Direction Pushover Analysis Column Assessment Results(Retrofitted Building-MaSTER FRAME® Columns-Design Earthquake)

B) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 2 % IN 50 YEARS (MAXIMUM CONSIDERED EARTHQUAKE)

In this section the retrofitted building is checked for the earthquake level with return period of 2500 years for life safety performance level.

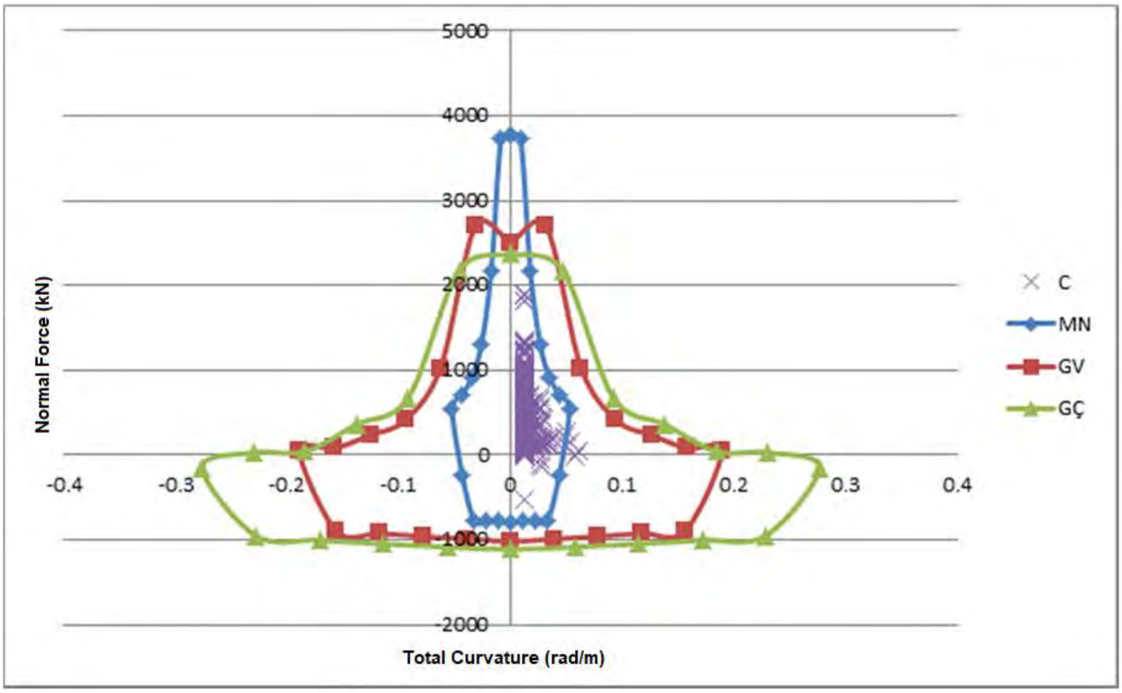


Figure 3.18c X Direction Pushover Analysis Column Assessment Results (Retrofitted Building-Existing Columns-MCE Earthquake)

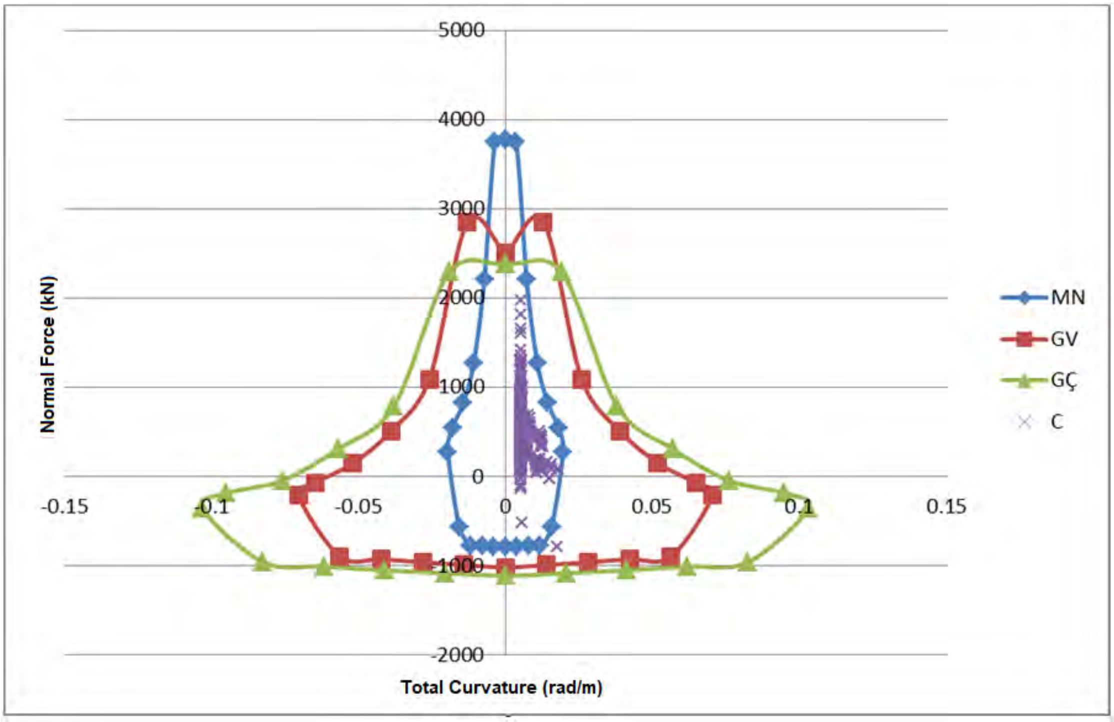


Figure 3.18d Y Direction Pushover Analysis Column Assessment Results (Retrofitted Building-Existing Columns-MCE Earthquake)

3.2.4.2. Fixed first mode pushover analysis shear wall results for 4 storey building with shear walls and retrofitted using MaSTER FRAME®

A) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 10 % IN 50 YEARS (DESIGN EARTHQUAKE)

The tables of the evaluation of the shear walls prepared according to the results of fixed first mode pushover analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-II-4** for DBE and **ATT-A-II-5** for MCE .
Axial load-curvature curves in Figure 3.19 and Figure 3.20 plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all shear walls in X and Y direction are in minimum damage level.

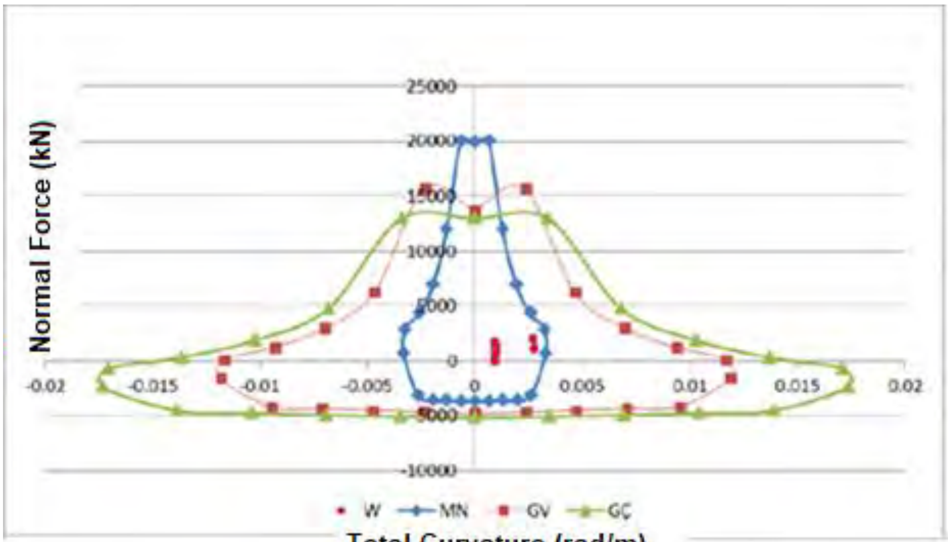


Figure 3.19 X Direction Pushover Analysis Shear Wall Assessment Results (Retrofitted Building-Existing Shear Walls-Design Earthquake)

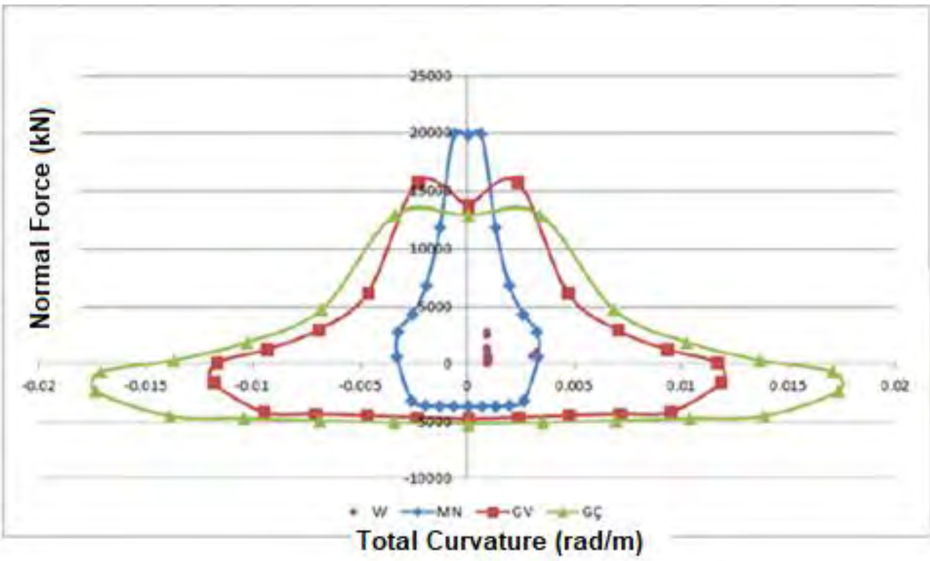


Figure 3.20 Y Direction Pushover Analysis Shear Wall Assessment Results (Retrofitted Building-Existing Shear Walls-Design Earthquake)

B) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 2 % IN 50 YEARS (MAXIMUM CONSIDERED EARTHQUAKE

In this section the retrofitted building is checked for the earthquake level with return period of 2500 years for life safety performance level.

Figure 3.20a X Direction Pushover Analysis Shear Wall Assessment Results (Retrofitted Building-Existing Shear Walls-MCE Earthquake)

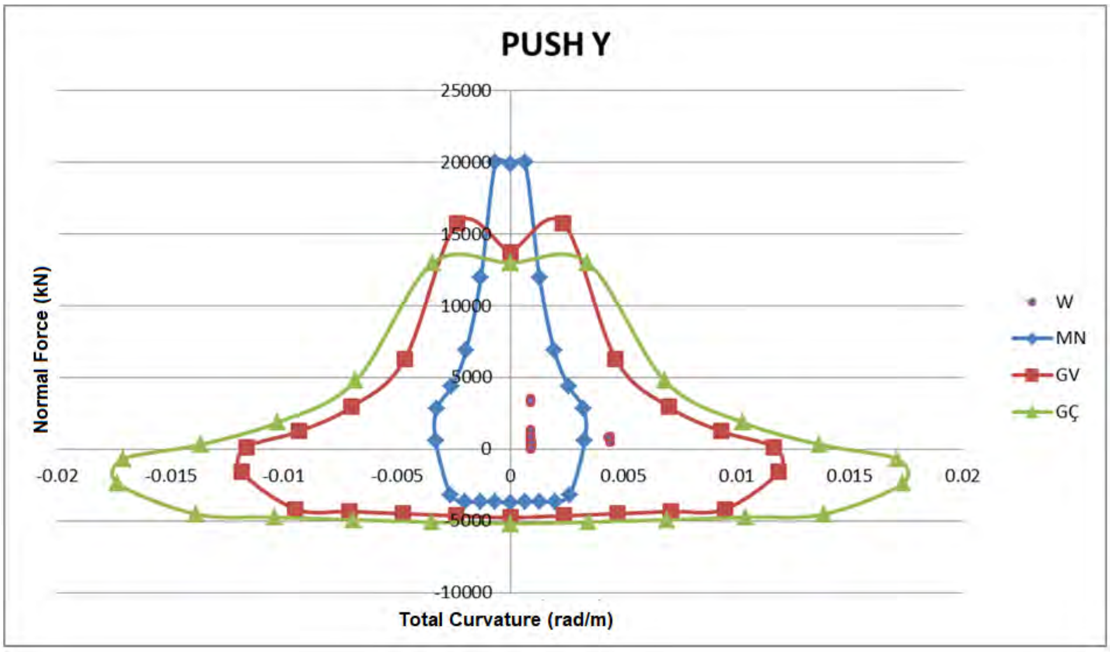


Figure 3.20b Y Direction Pushover Analysis Shear Wall Assessment Results (Retrofitted Building-Existing Shear Walls-MCE Earthquake)

3.2.4.3. Fixed first mode pushover analysis beam results for 4 storey building with shear walls and retrofitted using MaSTER FRAME®

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis under the effect of design earthquake for the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-II-6**.
It is seen in the table 3.13 that, 4 of 44 beams are in significant damage level. Beams of the MaSTER FRAME® system are also given it the same section. There is no damage in MaSTER FRAME® system beams.

All columns and shear walls of the 4 storey building with shear walls and retrofitted using MaSTER FRAME® have satisfied minimum damage level conditions for the design earthquake. That is why assessment of the beams for maksimum considered earthquake is not required.

Summary table of performance evaluation with fixed first mode pushover analysis for 4 storey building with shear walls and retrofitted using MaSTER FRAME®

All results given up to this section as diagrams and tables for 4 storey building with shear walls and retrofitted using MaSTER FRAME® under the effect of design earthquake are summarized in Table 3.13. Additionally assessment results of MaSTER FRAME® members are summarized in Table 3.13b. Performance analysis is performed both for design and maximum considered earthquake. The building is retrofitted using MaSTER FRAME® technique and assesment with fixed first mode pushover analysis concluded that the retrofitted building satisfies conditions of the code.

Under the effect of design earthquake;
All columns are in the X direction are in the minimum damage zone. 4 of the beams connected to shear walls are in the significant damage zone. All of the shear walls are in minimum damage zone.
All columns in the Y direction are in the minimum damage zone. 4 of the beams are in the significant damage zone. All of the shear walls are in minimum damage zone. 4 beams that are in significant damage level can be considered to increase building damping in X direction. That is why they are taken into consideration.

Under the effect of maximum considered earthquake;
All columns are in the life safety perfomans zone as it is shown in figüre 3.20a and 3.20b.
Figure 3.156a and 3.16b shows the capacity increase in both X and Y direction comparatively with addition of MaSTER FRAME® members.

As a result of performance analysis with fixed first mode pushover method, the 4 storey building with shear walls retrofitted using MaSTER FRAME®, satisfied the conditions of minimum performance level under the effect of design earthquake and life safety performance level under the effect of maximum considered earthquake.

Tablo 3.13 Summary Table of Assesment with Fixed First Mode Pushover Analysis Under Design Earthquake effect for 4 storey building retrofitted using MaSTER FRAME®

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME© / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	40/44	4/44	--	4/4	-	--
2nd storey	36/36	--	--	40/44	4/44	--	4/4	-	--
1st storey	36/36	--	--	40/44	4/44	--	4/4	-	--
Ground Floor	36/36	--	--	40/44	4/44	--	4/4	-	--

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME© / PUSH Y									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	36/38	2/38	--	6/6	--	--
2nd storey	36/36	--	--	34/38	4/38	--	6/6	--	--
1st storey	36/36	--	--	34/38	4/38	--	6/6	--	--
Ground Floor	36/36	--	--	34/38	4/38	--	6/6	--	--

Tablo 3.13b Summary Table of Assesment with Fixed First Mode Pushover Analysis Under Design Earthquake effect for MaSTER FRAME® system members of 4 storey building retrofitted using MaSTER FRAME®

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME© (MaSTER FRAME's Members) / PUSH X									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	8/8			6/6					
2nd storey	22/22	--	--	19/19	--	--	--	--	--
1st storey	22/22	--	--	19/19	--	--	--	--	--
Ground Floor	22/22	--	--	19/19	--	--	--	--	--

3.2.5. Perfomance evaluation with time history analysis of 4 storey building with shear walls retrofitted using MaSTER FRAME®

The 4 storey building has regular geometry and structural system. The mass participation factors of effective first mode for both directions are above 0.70. The study has done given in section 3.2.4 with this data, because it was appropriate to perform assesment with fixed first mode pushover analysis. Performance analysis with nonlinear time history method was performed in section 3.2.5 in order to confirm the pushover analysis. Acceleration records that are chosen for time history analysis were scaled to the design earthquake level.

3.2.5.1. Time History analysis column results for 4 storey building with shear walls and retrofitted using MaSTER FRAME® (TH)

The tables of the evaluation of the columns prepared according to the results of time history analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-III-1**.
Axial load-curvature curves in Figure 3.21 and Figure 3.22 plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all shear walls in X and Y direction are in minimum damage level.

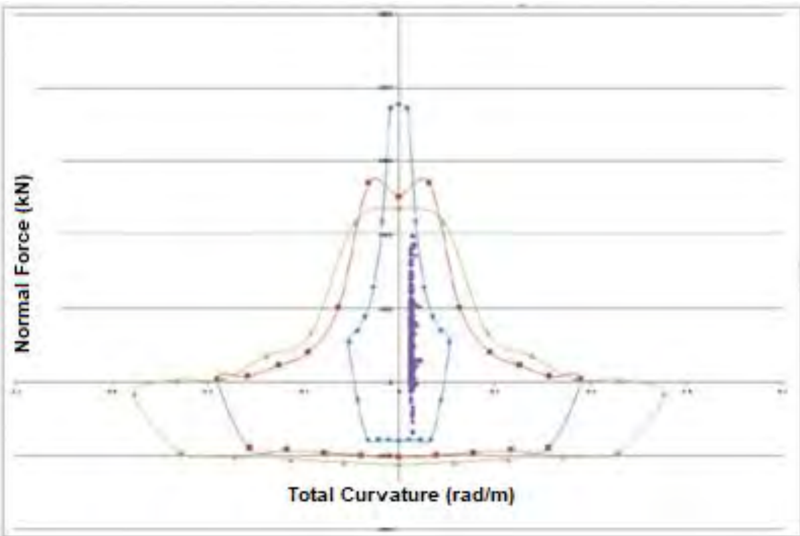


Figure 3.21 TH - X Direction Time History Analysis Column Assessment Results (Retrofitted Building-Existing Columns-Design Earthquake)

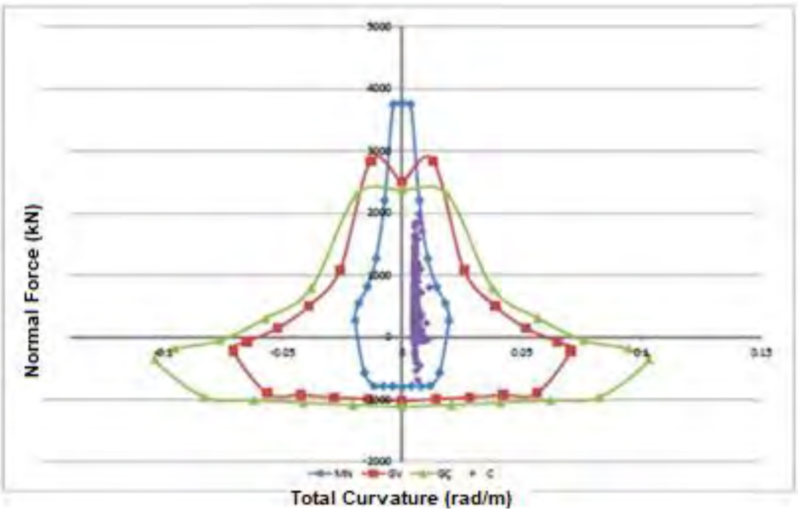


Figure 3.22 TH - Y Direction Time History Analysis Column Assessment Results (Retrofitted Building-Existing Columns-Design Earthquake)

3.2.5.2. Time History analysis shear wall results for 4 storey building with shear walls and retrofitted using MaSTER FRAME® (TH)

The tables of the evaluation of the shear walls prepared according to the results of time history analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-III-2**.
Axial load-curvature curves in Figure 3.23 and Figure 3. plotted for each damage limit, in order to summarize and visualize table data. When the shear wall curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all shear walls in X and Y direction are in minimum damage level..

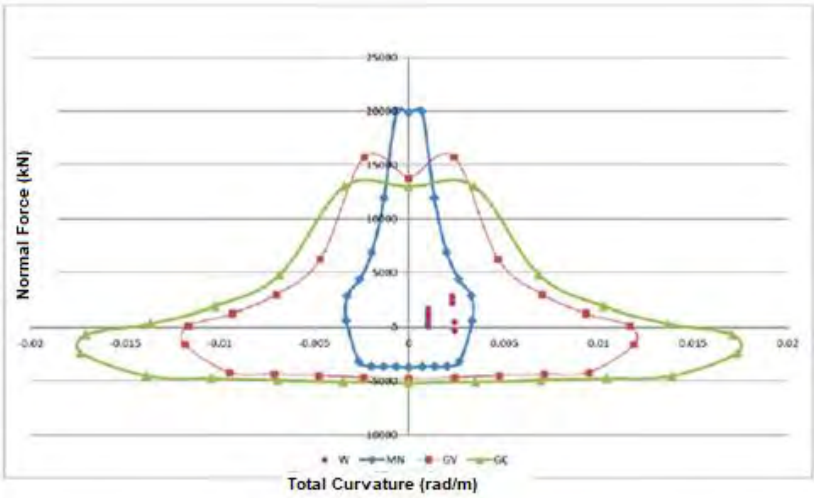


Figure 3.23 TH - X Direction Time History Analysis Shear Walls Assessment Results (Retrofitted Building-Existing Shear Walls-Design Earthquake)

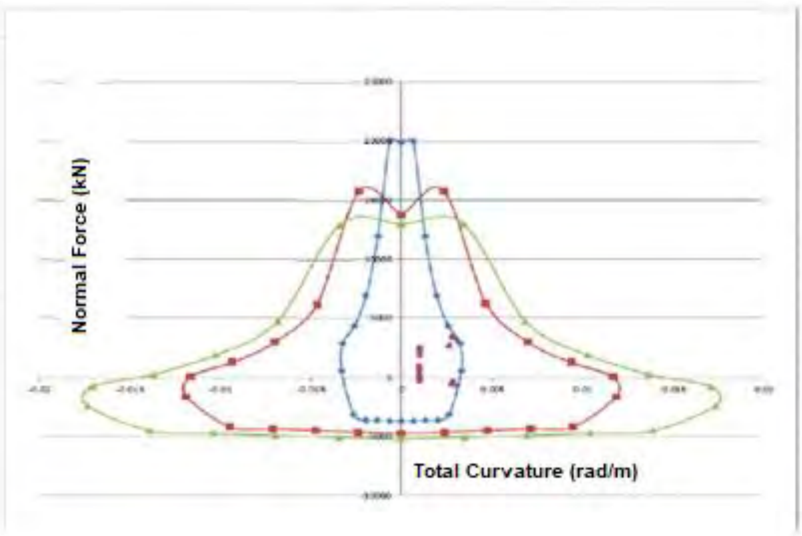


Figure 3.24 TH - Y Direction Time History Analysis Shear Walls Assessment Results (Retrofitted Building-Existing Shear Walls-Design Earthquake)

3.2.5.3. Time History analysis beam results for 4 storey building with shear walls and retrofitted using MaSTER FRAME® (TH)

The tables of the evaluation of the beams prepared according to the results of time history analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-A-III-3**. Because beams that appear in the tables with significant damage will not have a negative impact on the building behavior, their damage is ignored. It should be kept in mind that reinforcement of support regions of the beams of existing buildings are just assumption. There is no technology to determine exact reinforcement of that regions of the beams at the moment without sewere damage to the beam.

Summary table of performance evaluation with time history analysis for 4 storey building with shear walls and retrofitted using MaSTER FRAME® (for Design Earthquake)

It was shown with nonlinear fixed first mode pushover analysis method in previous sections of this report that, 4 storey building with shear walls retrofitted using MaSTER FRAME®, satisfied the conditions of minimum performance level under the effect of design earthquake and life safety performance level under the effect of maximum considered earthquake. Performance analysis with nonlinear time history method was performed to 4 storey building in this section in order to confirm the pushover analysis. Analysis results are summarized in Table 3.14. Because earthquake acceleration records were applied two-way both X and Y direction, element results in the summary table are given for both direction. All columns and shear walls were found to be at minimum damage level. It should be noted that beams that seems to have significant damage are adjacent to the shear walls. A small amount of beams that are adjacent to the shear walls, in the significant damage zone will make a positive contribution by increasing the overall damping of the structure.

Time history analysis which is performed in order to confirm fixed first mode pushover analysis has confirmed that 4 storey building with shear Wall and retrofitted using MaSTER FRAME® satisfies minimum damage performance level according to the DBYBHY 2007 criteria under the effect of design earthquake.

Table 3.14 Summary table of performance evaluation with time history analysis of 4 storey building with shear walls and retrofitted using MaSTER FRAME® for X and Y direction

4-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / Time History									
	COLUMN			BEAM			SHEAR WALL		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage
3rd storey	36/36	--	--	68/82	14/82	--	10/10	-	--
2nd storey	36/36	--	--	67/82	15/82	--	10/10	-	--
1st storey	36/36	--	--	67/82	15/82	--	10/10	-	--
Ground Floor	36/36	--	--	68/82	14/82	--	10/10	-	--

3.3. Performance Evaluation of Existing 3 Storey School Building without Shear with Fixed First Mode Pushover

3.3.1. Loads, material quality and earthquake parameters

Tablo 3.14 Summary Information for Existing 3 Storey School Building Without Shear Walls

Building Name	:	**Typical 3 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Structure Type	:	Reinforced Concrete Frame Type
Storey Height, Floor Area, # of Storey	:	2.9 m - 760 m2 - 3 storey
Total Area	:	2280 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Contribution Factor	:	0.60
Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Level Slab Loads	:	G=1.49 kN/m2, Q=2.25 kN/m2
Partician Wall Unit Weight	:	3.90 kN/m2
Foundation Type	:	Continous Footing
Target Performans	:	Immeditate Occupancy in the earthquake level with 10% exceedence probability in 50 years. Life Safety in the earthquake level with 2% exceedence probability in 50 years
Defined Cracked Section Rijidity Factors	:	Column and shear walls: I_{22},I_{33}=0.4 Beams: I_{33}=0.4

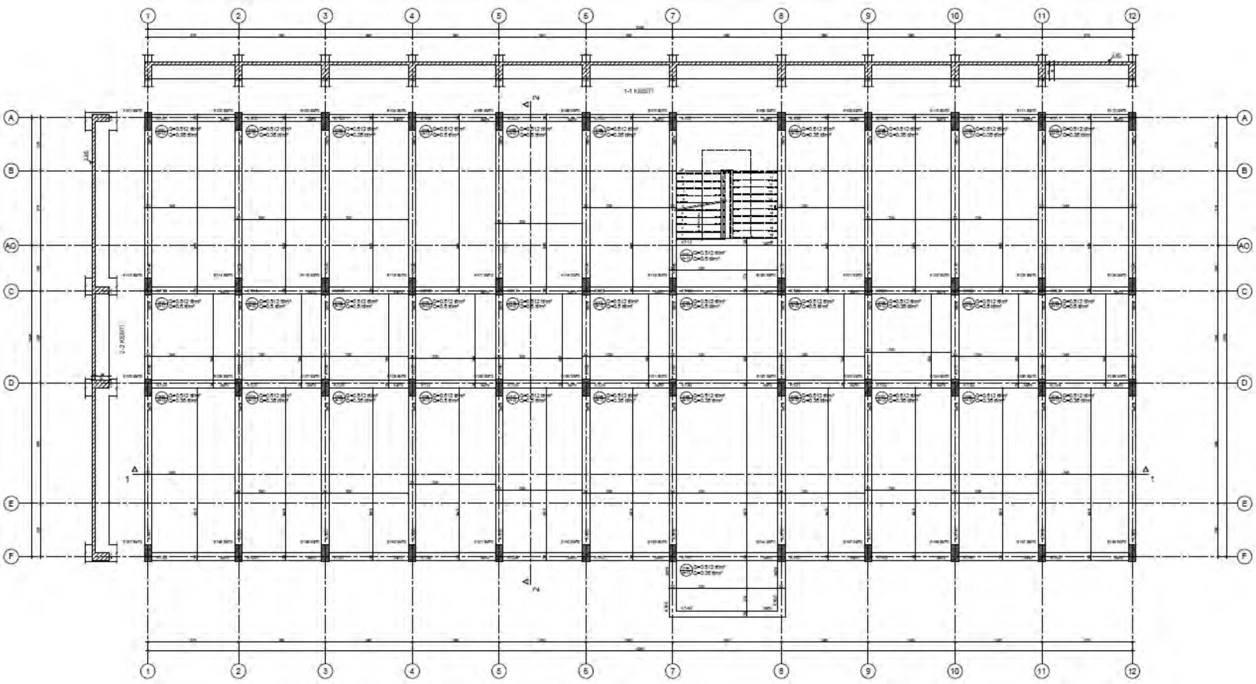


Figure 3.25 Existing 3 Storey Building Without Shear Walls

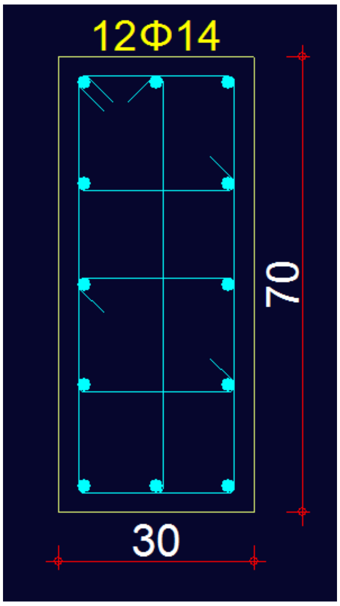


Figure 3.26 Column Reinf. Plan of 3 St. Build

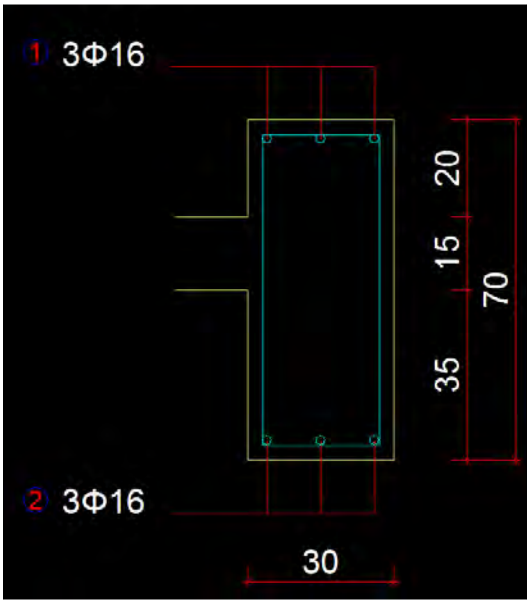


Figure 3.27 Beam Reinf. Plan of 3 St. Build

3.3.2. Modelling Structures in ETABS software

The building is modelled following the existing static plan in ETABS software using frame members for beams and columns. Dead and live loads on the slabs have been effected on beams by converting them to equivalent distributed loads. Cracked bending section rigidities defined in table 3.14 were used In the evaluation of the nonlinear performance of the structure.
3-D ETABS model of the structure can be seen in figüre 3.28'te verilmiştir.

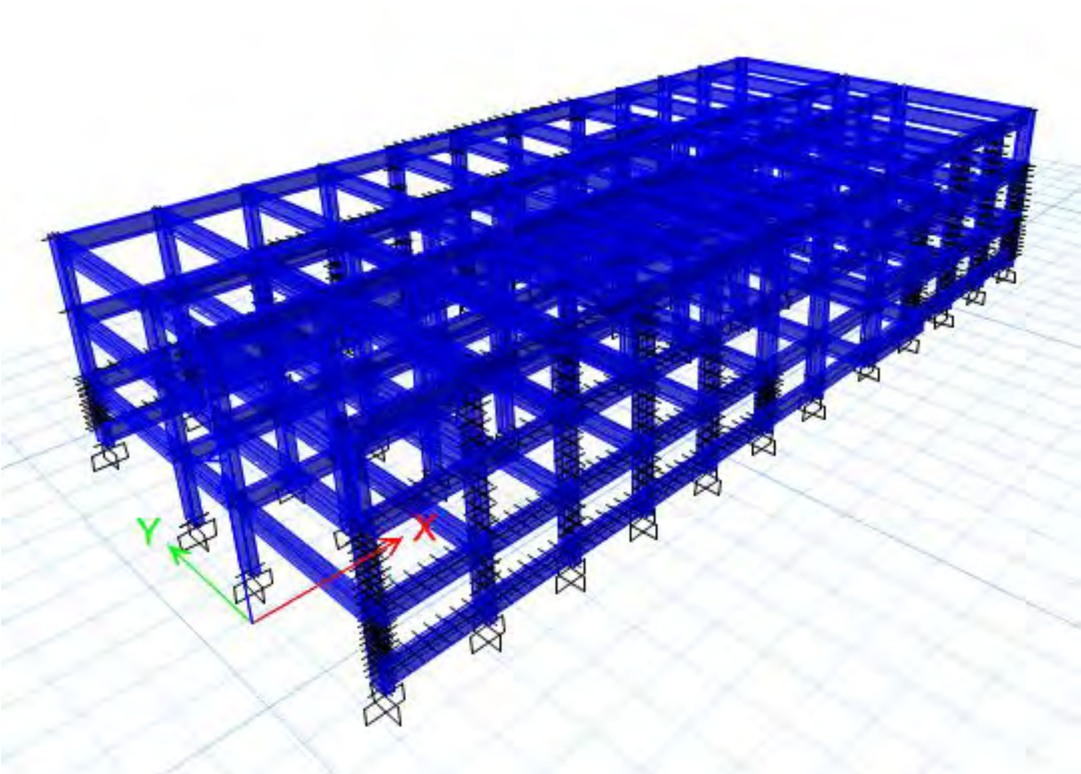


Figure 3.28 3D ETABS model of 3 storey existing structure

3.3.3. Dynamic analysis of the structure

Table 3.15 shows the modal period and mass participation ratios of the building and table 3.16 shows the storey masses used in the earthquake analysis.

Tablo 3.15 Modal Periods and Mass Participation Ratios of Existing 3 Storey Building

Modal Mass Participation Ratios 3 STOREY EXISTING MODEL				
Case	Mode	Period	UX	UY
		sec		
Modal	1	0.621	0.8629	0
Modal	2	0.528	6.68E-06	0.837
Modal	3	0.502	0.0004	0.0084
Modal	4	0.255	0.107	0
Modal	5	0.18	0.0296	0
Modal	6	0.161	5.94E-07	0.1144
Modal	7	0.157	9.3E-06	0.0066
Modal	8	0.09	8.55E-07	0.0107
Modal	9	0.089	0	0.023
Modal	10	0.056	6.26E-07	0
Modal	11	0.056	1.34E-06	0
Modal	12	0.056	0	0
Modal	13	0.049	0	1.89E-06
Modal	14	0.042	0	0
Modal	15	0.036	0	2.04E-06
Modal	16	0.035	0	3.46E-06
Modal	17	0.032	0	0
Modal	18	0.031	0	5.4E-07
Modal	19	0.031	0	0
Modal	20	0.029	0	0

T_x= 0.62 s
T_y= 0.52 s

Table 3.16 3 Storey Existing Model Storey Masses used for Earthquake Analysis

Storey No	W (kN)
1	10660.438
2	10638.278
3	8313.914
Total	29612.63

3.3.4. Pushover analysis of 3 storey building without shear walls and determination of target displacement.

Calculated values at the moment the structure is pushed until 4% total drift by multiplying storey masses and related modal amplitudes are shown in figüre 3.29 and Figure 3.30.

Table 3.17 Calculation of Effective Storey Mass and Modal Amplitude for Existing 3 Storey Building without Shear Wall

1. Period X direction 0.62 s

Storey No	W (kN)	m_i	Φ_{xi}	$m_i\Phi_{i1(x)}$	L_{xn}	$m_i\Phi_{i1}^{2(x)}$	M_n	M_{xn}	Oran	Γ_{x1}
1	10660.438	1086.691	0.0090	9.78021835	51.57	0.088022	1.01	2635.44	0.87	51.10
2	10638.278	1084.432	0.0190	20.6042082		0.39148				
3	8313.914	847.4938	0.0250	21.1873445		0.529684				
						0				
Total	29612.63	3018.617								

2. Period Y direction 0.52 s

Storey No	W (kN)	m_i	Φ_{yi}	$m_i\Phi_{i1(y)}$	L_{yn}	$m_i\Phi_{i1}^{2(y)}$	M_n	M_{yn}	Oran	Γ_{y1}
1	10660.438	1086.691	0.008	8.69352742	51.33	0.069548	1.03	2548.55	0.84	49.65
2	10638.278	1084.432	0.019	20.6042082		0.39148				
3	8313.914	847.4938	0.026	22.0348383		0.572906				
						0				
Total	29612.63	3018.617								

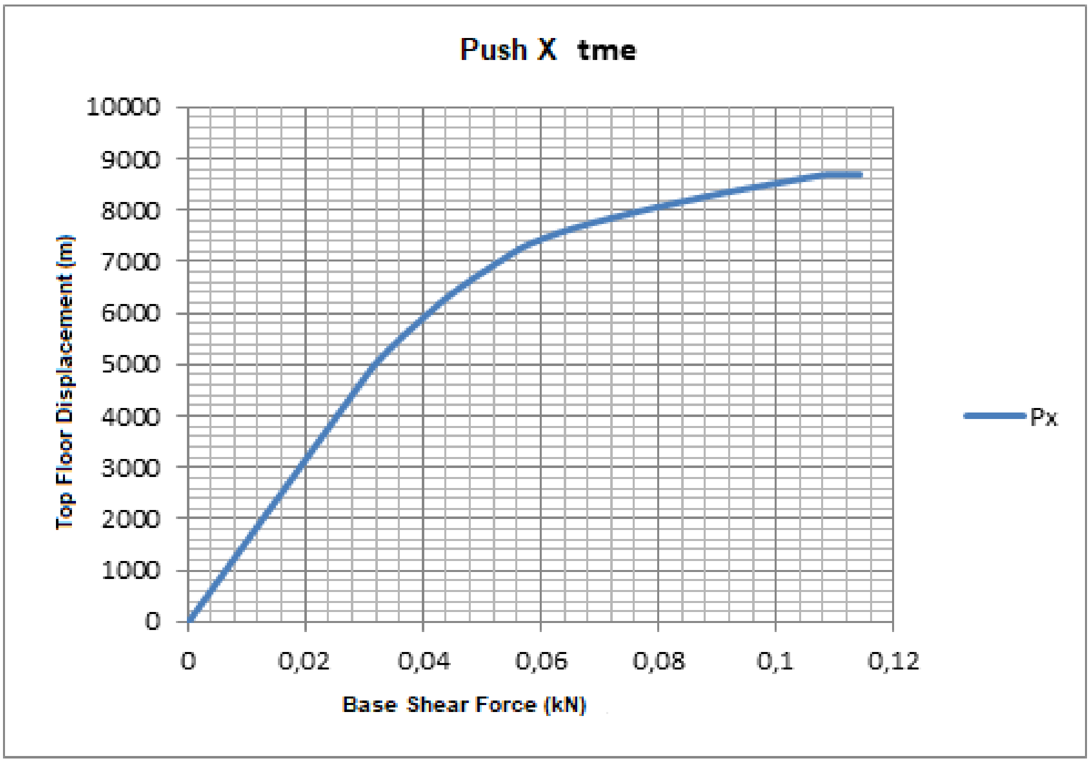


Figure 3.29 Existing 3 Storey Building Base Shear Force-Top Floor Displacement Diagram for Y Dir.

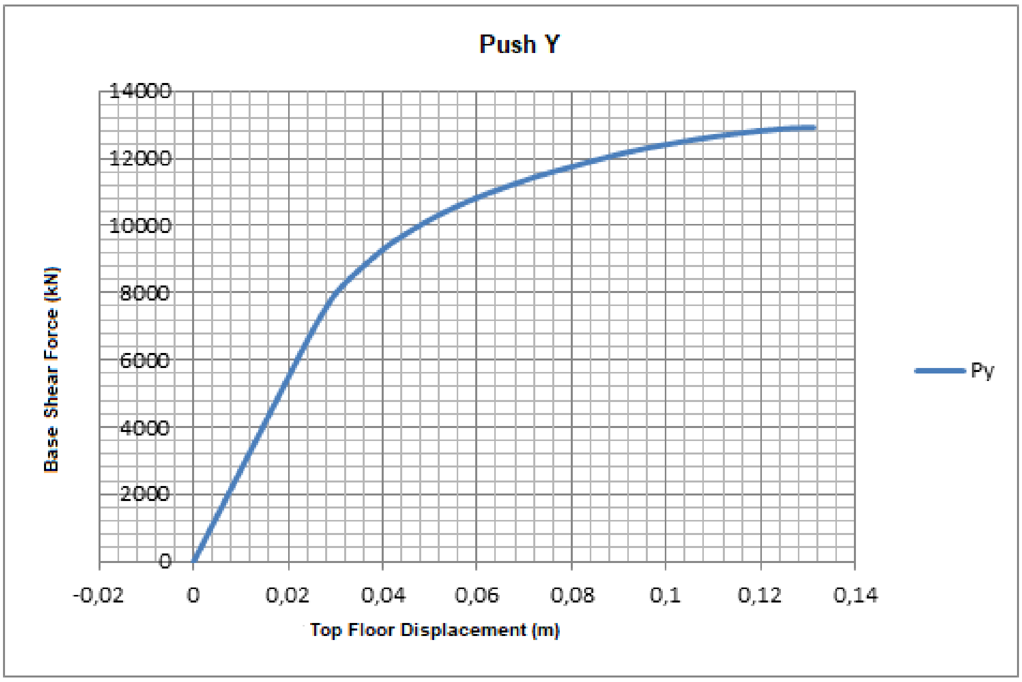


Figure 3.30 Existing 3 Storey Building Base Shear Force-Top Floor Displacement Diagram for Y Dir

After pushover analysis have performed for both directions, target displacements are calculated as it is described in section2.6.1.1. (Tablo 3.18).

Tablo 3.18 Calculation of Modal displacement demand for Existing 3 Storey Building without Shear Wall.

									target displacement (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.62	2.435273	9.556011	0.974109	0.093047					0.12
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.52	2.5	9.81	1	0.067192	4.021894	2.439149	1.090772	0.073291	0.09

3.3.4.1. Fixed first mode pushover analysis column results for 3 storey existing building without shear walls (Design Earthquake Level)

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis of the existing 4 storey structure with shear walls are given in, **ATT-B-I-1**.
Axial load-curvature curves in Figure 3.31 and Figure 3.32 is plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that there are members in collapse prevention and collapse damage zone in X direction. All columns in Y direction are in minimum damage level.

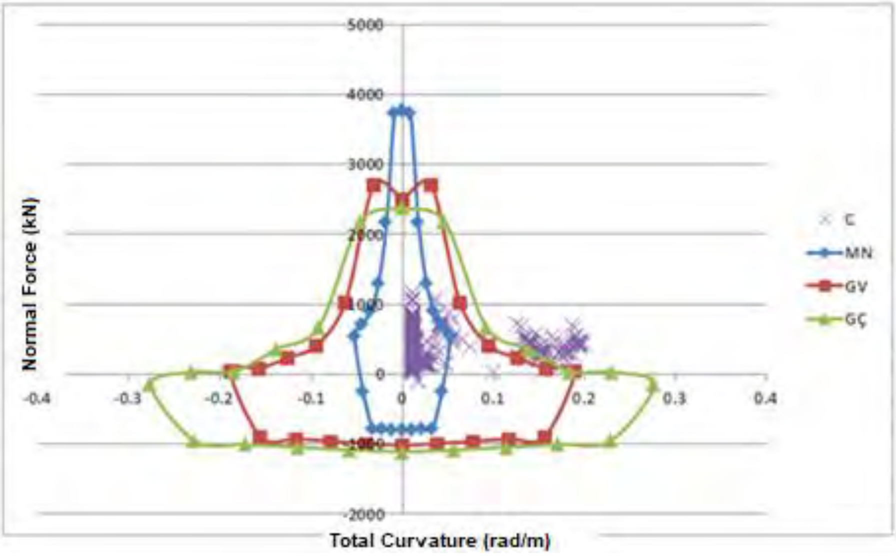


Figure 3.31 X Y Direction Pushover Analysis Existing Column Asessment Results

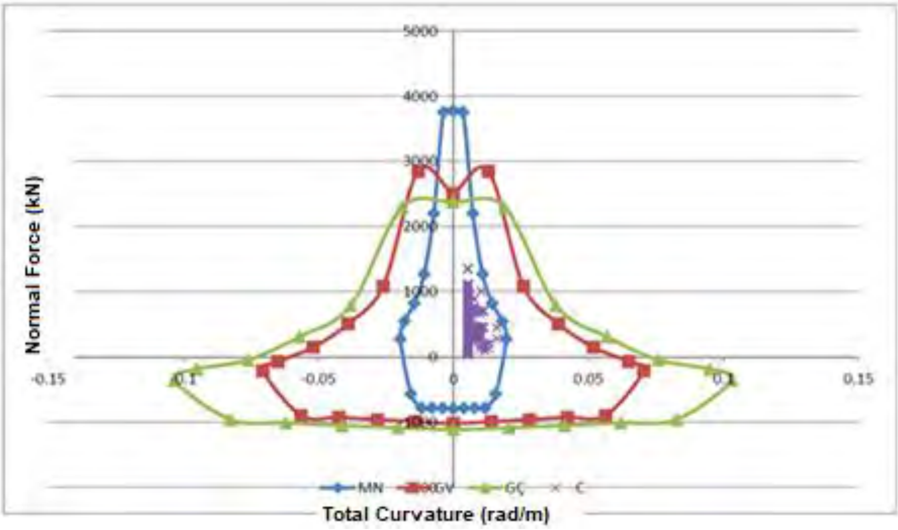


Figure 3.32 Y Y Direction Pushover Analysis Existing Column Asessment Results

3.3.4.2. Fixed first mode pushover analysis beam results for 3 storey existing building without shear walls (Design Earthquake Level)

The tables of the evaluation of the beams prepared according to the results of fixed first mode pushover analysis of the existing 3 storey structure without shear walls are given in, **ATT-B-I-2**.
It is seen in the tablet that. There are beams are in significant and sever damage zone.

Summary table of performance evaluation with fixed first mode pushover analysis for existing 3 storey building without shear walls

All results given up to this section as diagrams and tables are summarized in Table 3.19.
There are columns and beams in X direction in the siginificant and sever damage zone in design earthquake level. 3 storey frame type building does not satisfy code conditions under the effect of design earthquake for X direction. Buildings need to be retrofitted.
All columns in the Y direction are in the minimum damage zone, 7 beams are in the significant damage zone. If 7 beams are ignored due to the reasons explained in section 3.2.5.3, 3 storey existing frame type building satisfies code conditions for Y direction.
Retrofitting of the 3 storey existing building will be studied in order to strengthen the weakness in X direction.

Table 3.19 Summary table of performance evaluation with fixed first mode pushover analysis of existing 3 storey building without shear walls for X and Y direction

Existing 3-Story Structure / PUSH X							
	COLUMN				BEAM		
	Min Damage	Marked Damage	Advanced Damage	Collapse	Min Damage	Marked Damage	Advanced Damage
2nd storey	48/48	--	--	--	44/44	--	--
1st storey	25/48	2/48	6/48	15/48	35/44	9/44	--
Ground Floor	33/48	15/48	--	--	36/44	7/44	1/44

Existing 3-Story Structure / PUSH Y							
	COLUMN				BEAM		
	Min Damage	Marked Damage	Advanced Damage	Collapse	Min Damage	Marked Damage	Advanced Damage
2nd storey	48/48	--	--	--	44/44	0/44	--
1st storey	48/48	--	--	--	32/44	12/44	--
Ground Floor	48/48	--	--	--	27/44	10/44	7/44

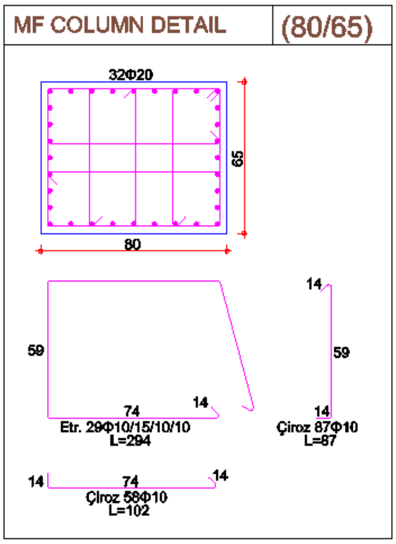
3.4. Performance Evaluation with Fixed First Mode Pushover Analysis of 3 Storey School Building without Shear Walls and Strengthened using MaSTER FRAME®

3.4.1. Loads, material quality and earthquake parameters

Tablo 3.20 MaSTER FRAME® Uygulanmış 3 Katlı Perdesiz Yapı Özet Bilgileri

Building Name	:	**Typical 3 Storey School Building**
Address	:	**Türkiye**
Construction Date	:	Before 2000
Structure Type	:	Reinforced concrete frame type (without shear walls)
Storey Height, Floor Area, # of Storey	:	2.9 m 760 m2 3 storey
Total Area	:	2280 m2
Existing Concrete Quality, Reinforcement Type	:	15,0 MPa – ST III
MaSTER FRAME® Concrete Quality, Reinforcement Type	:	30 MPa – ST III
MaSTER FRAME® members-existing members anchorage type	:	MaSTER Disk-Ankraj®
Soil Type	:	Z3 C
Earthquake Zone	:	I
Live Load Contribution Factor	:	0.60
Slab Loads	:	G=2.12 kN/m2, Q=3.50 kN/m2
Roof Level Slab Loads	:	G=1.49 kN/m2, Q=2.25 kN/m2
Partition Wall Unit Weight	:	3.90 kN/m2
Foundation Type	:	Continous Footing
Defined Cracked Section Rijidity Factors	:	Column : I22,I33=0.4 Beams: I33=0.4

The same MaSTER FRAME® memberr have been used for 3 storey building as 4 storey building with different management. (Figure 3.33).



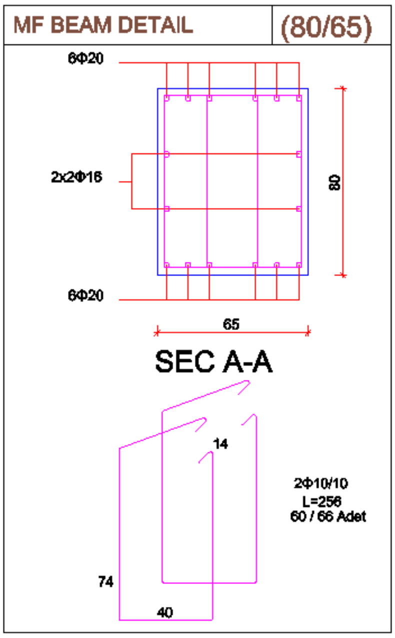


Figure 3.33 MaSTER FRAME® Column and Beam Section Plan

3.4.2. Modelling Structures in ETABS software

The building is modelled following the existing static plan in ETABS software using, frame members for beams and columns. Dead and live loads on the slabs have been effected on beams by converting them to equivalent distributed loads. Cracked bending section rigidities defined in table 3.20 were used In the evaluation of the nonlinear performance of the structure.
3-D ETABS model of the structure can be seen in figürel 3.34’te verilmiştir.

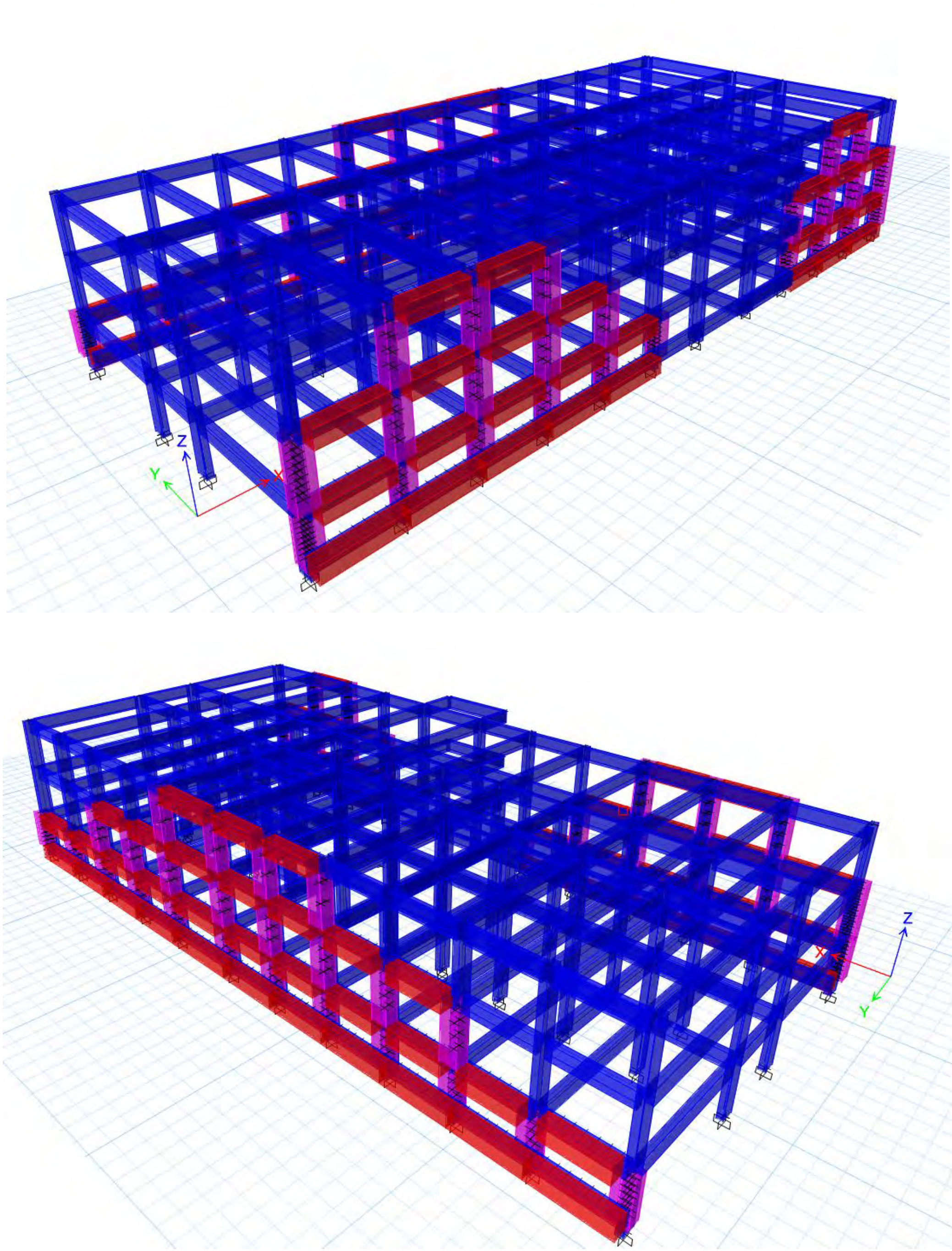


Figure 3.34 3D ETABS model of 3 storey structure retrofitted using MaSTER FRAME®

3.4.3. Dynamic analysis of the structure

Table 3.21 shows the modal period and mass participation ratios of the building and table 3.22 shows the storey masses used in the earthquake analysis..

Table 3.21 Modal Periods and Mass Participation Ratios of 3 Storey Building Without Shear Walls Strengthened using MaSTER FRAME®

Modal Mass Participation Ratios 3 Storey Building with MaSTER FRAME(c)				
Case	Mode	Period	UX	UY
		sec		
Modal	1	0.524	0	0.8383
Modal	2	0.374	0.0375	3.01E-05
Modal	3	0.331	0.8027	0
Modal	4	0.151	0.0001	0.1278
Modal	5	0.147	0.1192	0.0001
Modal	6	0.13	0.0006	0.0002
Modal	7	0.095	0.0393	0
Modal	8	0.078	2.51E-06	0.0331
Modal	9	0.072	2.42E-05	0.0005
Modal	10	0.023	3.84E-05	0
Modal	11	0.022	0.0004	0
Modal	12	0.02	7.44E-06	0
Modal	13	0.02	0	0
Modal	14	0.02	0.0001	0
Modal	15	0.02	0.0001	1.09E-06
Modal	16	0.019	0	8.92E-07
Modal	17	0.019	1.51E-06	0
Modal	18	0.019	1.71E-06	0
Modal	19	0.019	5.51E-07	0
Modal	20	0.019	0	0

Tablo 3.22 3 Storey Building Model Retrofitted Using MaSTER FRAME® Storey Masses used for Earthquake Analysis

Storey No	W (kN)
1	13403.000
2	11661.000
3	8773.000
Total	33837

3.4.4. Fixed first mode Pushover analysis of the 3 storey building without shear Wall retrofitted using MaSTER FRAME® and determination of target displacement

Calculated values at the moment the structure is pushed until 4% total drift by multiplying storey masses and related modal amplitudes are shown in figüre 3.35 and 3.36.

Table 3.23 Calculation of Effective Storey Mass and Modal Amplitude for 3 Storey Building without Shear Wall and retrofitted using MaSTER FRAME®

3. Period X direction 0.34 s

Storey No	W (kN)	m_i	$\Phi_{i1(x)}$	$m_i\Phi_{i1(x)}$	L_{xn}	$m_i\Phi_{i1}^{2\,(x)}$	M_n	M_{xn}	Oran	Γ_{x1}
1	13403.000	1366.259	0.0080	10.9300714	53.50	0.087441	0.99	2890.91	0.84	54.04
2	11661.000	1188.685	0.0170	20.2076453		0.34353				
3	8773.000	894.2915	0.0250	22.3572885		0.558932				
Total	33837	3449.235								

1. Period Y direction 0.53 s

Storey No	W (kN)	m_i	$\Phi_{i1(y)}$	$m_i\Phi_{i1(y)}$	L_{yn}	$m_i\Phi_{i1}^{2\,(y)}$	M_n	M_{yn}	Oran	Γ_{y1}
1	13403	1366.259	0.008	10.9300714	54.68	0.087441	1.03	2898.97	0.84	53.01
2	11661	1188.685	0.018	21.3963303		0.385134				
3	8773	894.2915	0.025	22.3572885		0.558932				
Total	33837	3449.235								

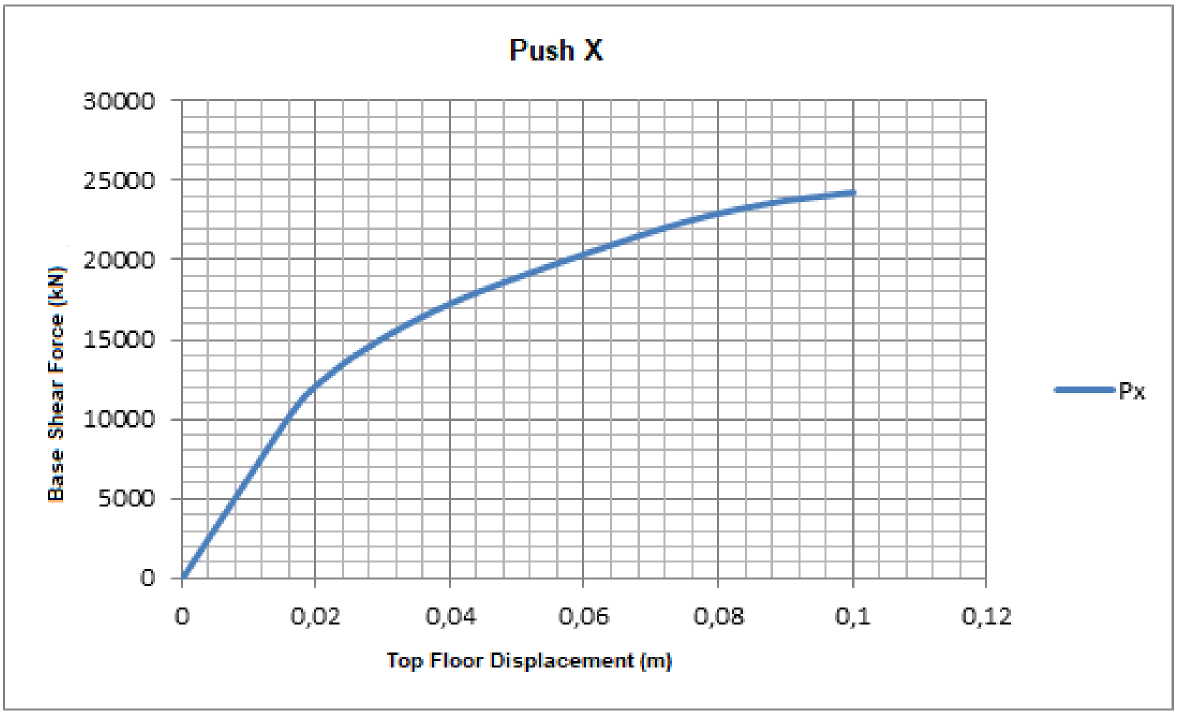


Figure 3.35 3 Storey Building Retrofitted using MaSTER FRAME® Base Shear Force-Top Floor Displacement Diagram for X Dir

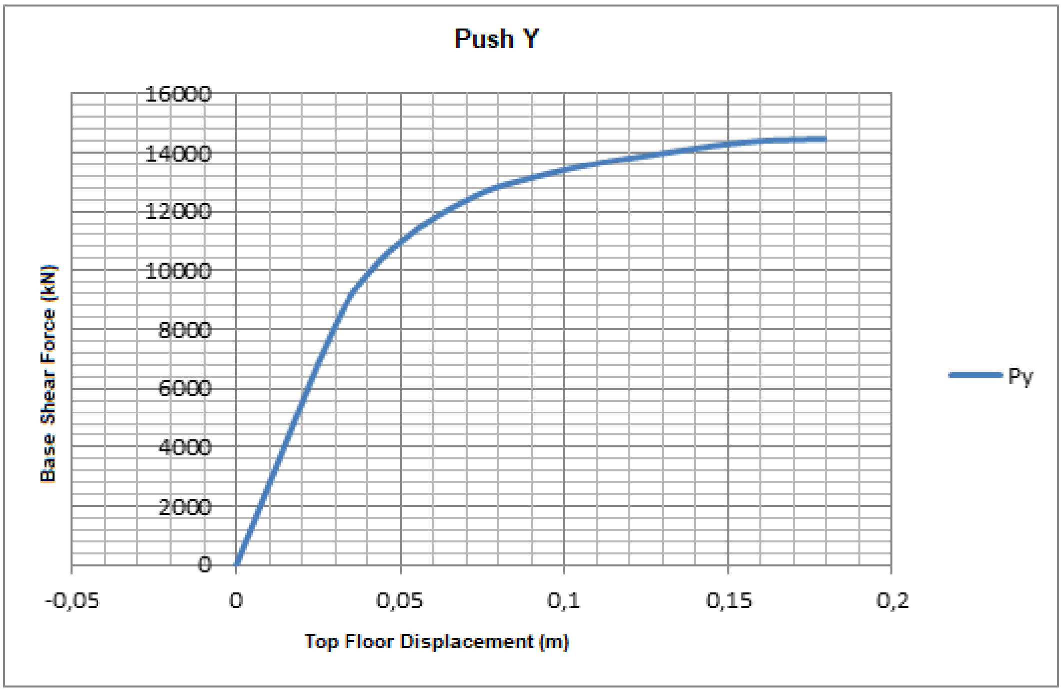


Figure 3.36 3 Storey Building Retrofitted Using MaSTER FRAME® Base Shear Force-Top Floor Displacement Diagram for Y Dir

Comparison of Pushover Diagrams for Retrofitted an Not Retrofitted models

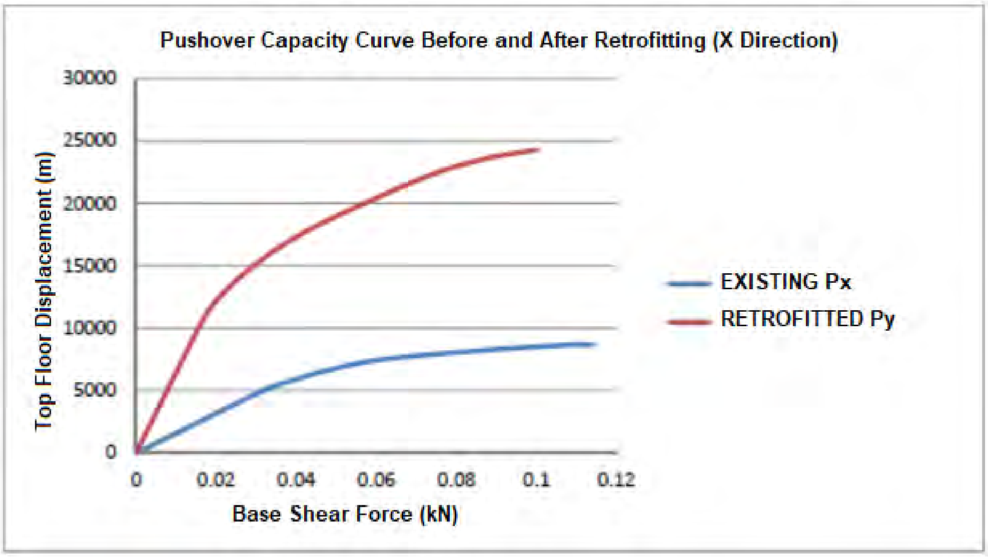


Figure 3.36a Pushover Diagrams of 3 Storey Building Before and After Retrofitting (X Direction)

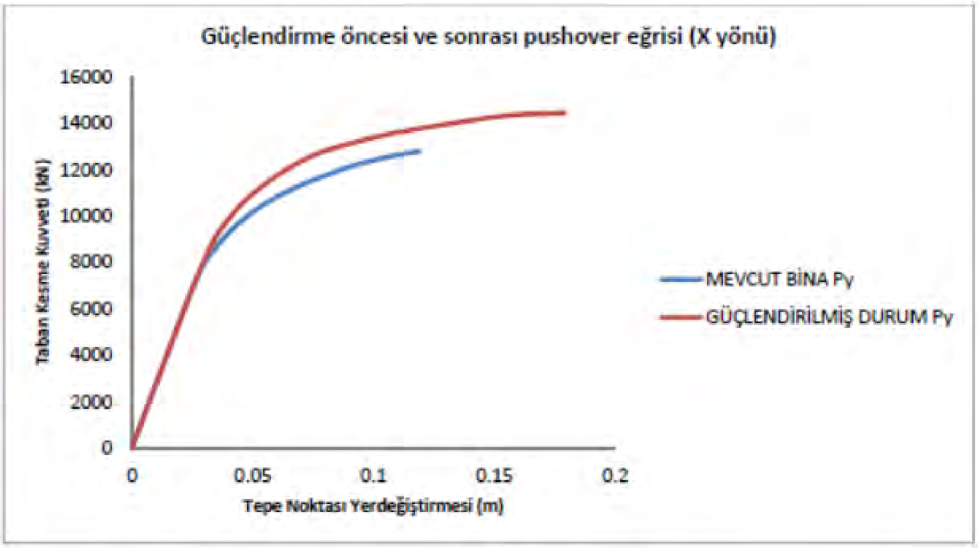


Figure 3.36b Pushover Diagrams of 3 Storey Building Before and After Retrofitting (Y Direction)

After pushover analysis have performed for both directions, target displacements are calculated as it is described in section 2.6.1.1 (Tablo 3.24).

Tablo 3.24a Calculation of Modal displacement demand for 3 Storey Building without Shear Wall and retrofitted using MaSTER FRAME® (for design earthquake level)

									target displacement (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.33	2.5	9.81	1	0.027061	5.811327	1.688082	1.333501	0.036085	0.049
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdl1	uyN1
0.52	2.5	9.81	1	0.067192	4.208393	2.331056	1.087848	0.073094	0.097

Table 3.24b Calculation of Modal displacement demand for 3 Storey Building without Shear Wall and retrofitted using MaSTER FRAME® (for maximum considered earthquake level)

									target displacement (m)
Tx	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uxN1
0.33	2.5	14.715	1.5	0.040591	5.811327	2.532124	1.495061	0.060686	0.081987575
Ty	S(T)	Sae(T)	Sae(T)/g	Sde (m)	ay1	Ry1	CR1	Sdi1	uyN1
0.54	2.5	14.715	1.5	0.10869	4.208393	3.496584	1.079334	0.117312	0.155478267

3.4.4.1. Fixed first mode pushover analysis column results for 3 storey building without shear walls and retrofitted using MaSTER FRAME®

A) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 10 % IN 50 YEARS (DESIGN EARTHQUAKE)

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis of the 3 storey structure without shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-B-II-1**.

Axial load-curvature curves in Figure 3.37 plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all columns in X direction are in minimum damage level. Because all columns in Y direction were in minimum damage level in existing condition they are not reassesed.

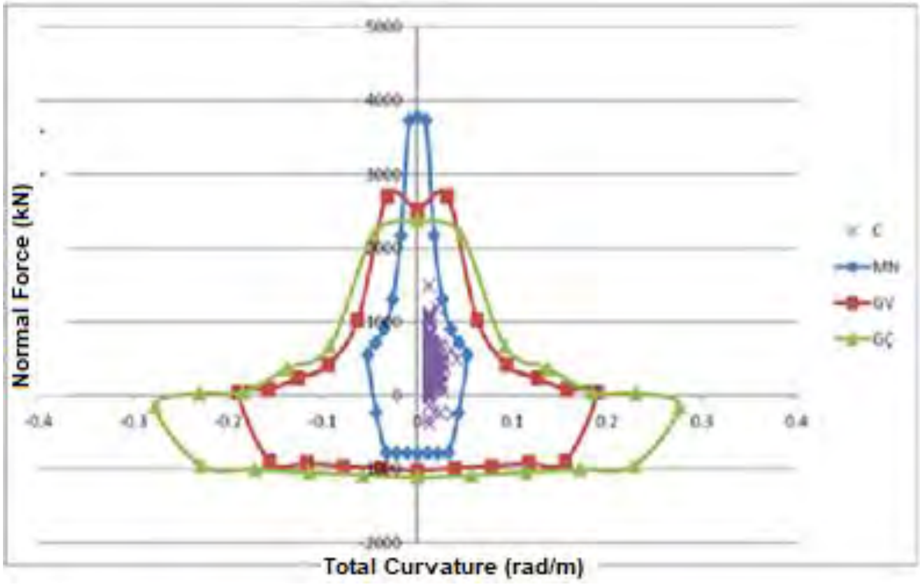


Figure 3.37a X Direction Pushover Analysis Column Assessment Results(Retrofitted Building-Existing Columns-Design Earthquake)

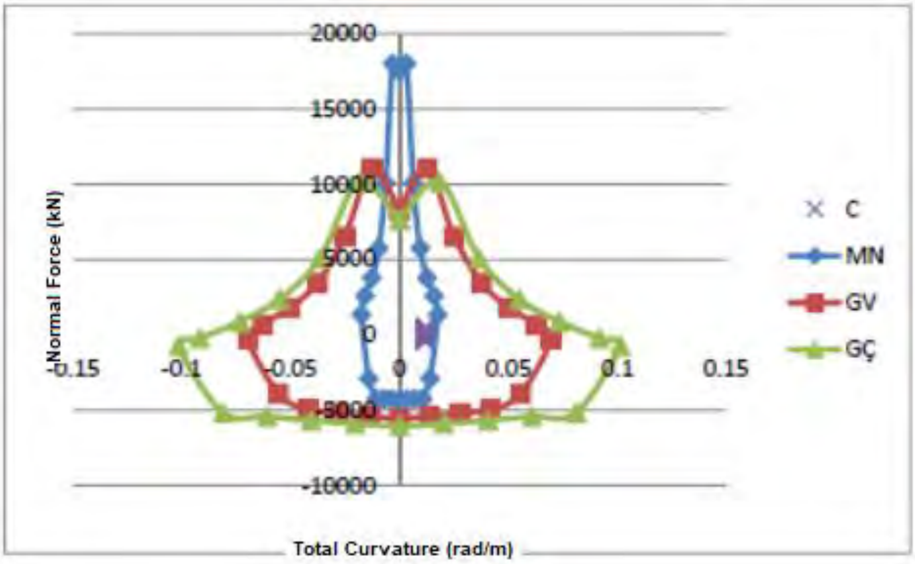


Figure 3.37b X Direction Pushover Analysis Column Assessment Results(Retrofitted Building-MaSTER FRAME® Columns-Design Earthquake)

B) EARTHQUAKE LEVEL WİTH EXCEEDENCE POSSIBILITY 2 % IN 50 YEARS (MAXIMUM CONSIDERED EARTHQUAKE – MCE)

In this section the retrofitted building is checked for the earthquake level with return period of 2500 years for life safety performance level.

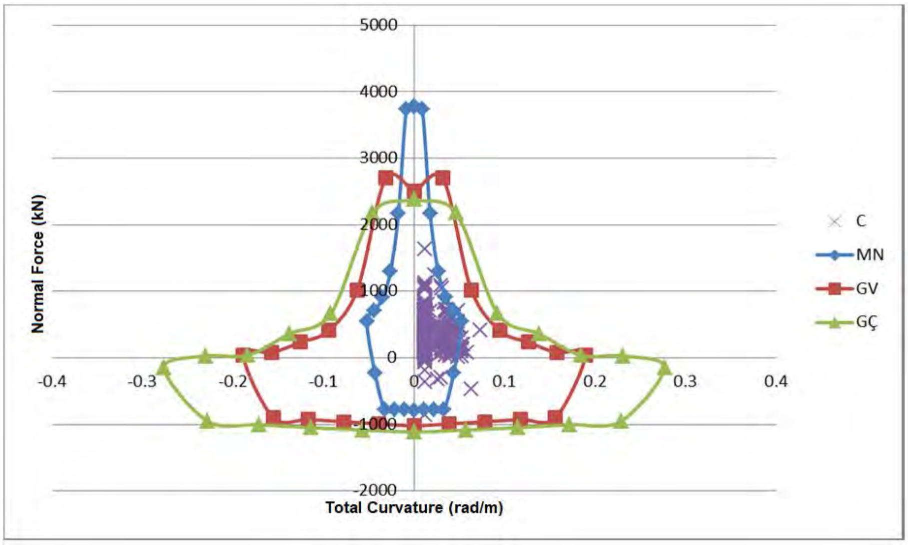


Figure 3.37c X Direction Pushover Analysis Column Assessment Results (Retrofitted Building-Existing Columns-MCE Earthquake)

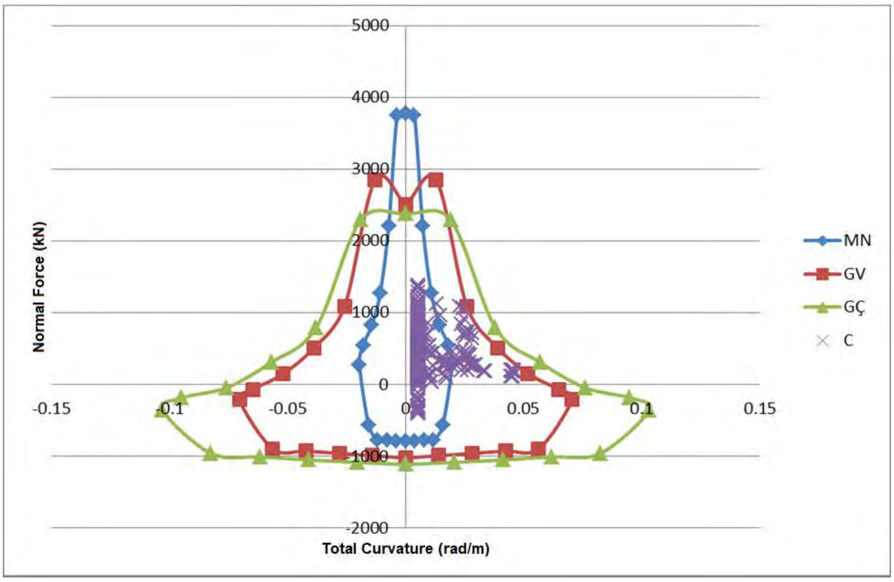


Figure 3.37d Y Direction Pushover Analysis Column Assessment Results (Retrofitted Building-Existing Column-MCE Earthquake)

3.4.4.2. Fixed first mode pushover analysis beam results for 3 storey building without shear walls and retrofitted using MaSTER FRAME®

The tables of the evaluation of the columns prepared according to the results of fixed first mode pushover analysis of the 3 storey structure without shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-B-II-2**.
It is seen in the table 3.25, 4 of 44 beams are in significant damage level. This amount of damage is in code limits. Beams of the MaSTER FRAME® system are also given in the same table. There is no damage in MaSTER FRAME® system beams.

All columns and beams of 3 storey frame type building retrofitted using MaSTER FRAME® have been satisfied conditions of the code. That is why it is not needed to reasses the beams for life safety damage level under the effect of MCE earthquake level.

Summary table of performance evaluation with fixed first mode pushover analysis for 3 storey building without shear walls and retrofitted using MaSTER FRAME®

All results given up to this section as diagrams and tables and details listed in **ATT-B-II** for 3 storey building without shear walls and retrofitted using MaSTER FRAME® under the effect of design earthquake are summarized in Table 3.25.
Additionally columns of the retrofitted 3 storey building are assessed under the affect of MCE. Results of this assessment are given in **ATT-B-II-3**. All columns satisfies conditions of minimum damage level under effect of DBE and life safety damage level under effect of MCE. Increases in capacity with addition of MaSTER FRAME® members are given in Figure 3.36a and 3.36b comparitively. Although MaSTER FRAME® members were added in X direction, there is significant capacity increase in Y direction as well.

As a result 3 storey frame type building retrofitted using MaSTER FRAME® satisfied the conditions of Immediate Occupancy damage level under the effect of design earthquake and Life Safety dama level under the effect of maximum considered earthquake as per DBYBHY 2007.

Table 3.25 Summary Table of 3 Storey Frame Type Building Retrofitted Using MaSTER FRAME® with Fixed First Mode Pushover Analysis Method under the effect of Design Earthquake

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME© / PUSH X									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	48/48	--	--	44/44	--	--	--	--	--
1st storey	48/48	--	--	44/44	--	--	--	--	--
Ground Floor	48/48	--	--	40/44	4/44	--	--	--	--

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME© (MaSTER FRAME's Members) / PUSH X									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	9/9	--	--	6/6	--	--	--	--	--
1st storey	17/17	--	--	14/14	--	--	--	--	--
Ground Floor	22/22	--	--	19/19	--	--	--	--	--

3.4.5. Perfomance evaluation with time history (TH) analysis of 3 storey building without shear walls retrofitted using MaSTER FRAME®

The 3 storey building which has been retrofitted using MaSTER FRAME® have a regular geometry and structural system. Effective first mode mass participation ratios are above 0.70 for both directions. Because structural properties of the studied building was convinient for fixed first mode pushover analysis, studies described in section 3.4 were performed. For the confirmation purpose nonlinear time history analysis were performed and described in section 3.5.

3.4.5.1. Assessment results of 3 storey building columns without shear walls retrofitted using MaSTER FRAME® with time history analysis method (TH)

The tables of the evaluation of the columns prepared according to the results of time history analysis of the 3 storey buildin without shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-B-III-1**

Axial load-curvature curves in Figure 3.38 and Figure 3.39 plotted for each damage limit, in order to summarize and visualize table data. When the column curvatures obtained as a result of analysis were placed in the diagrams, it is seen that all shear walls in X and Y direction are in minimum damage level.

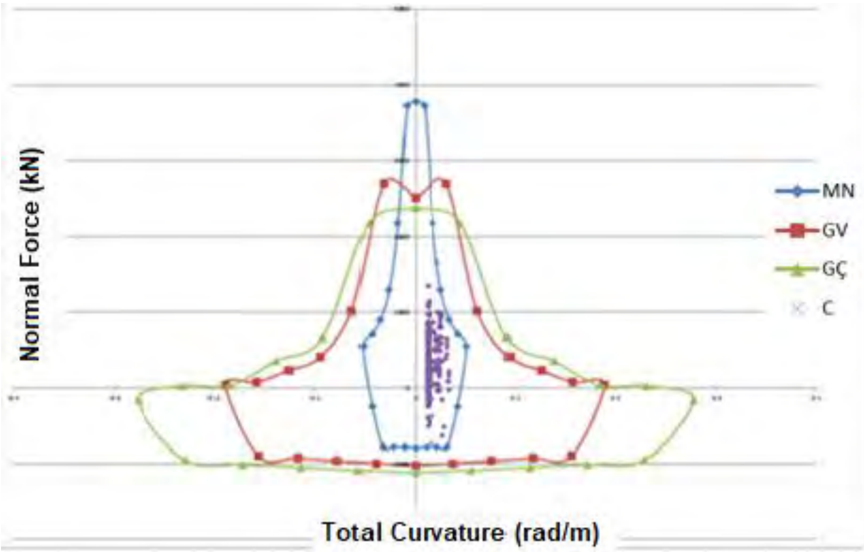


Figure 3.38 X Direction Time History Analysis Column Assessment Results (Retrofitted Building-Existing Columns-Design Earthquake)

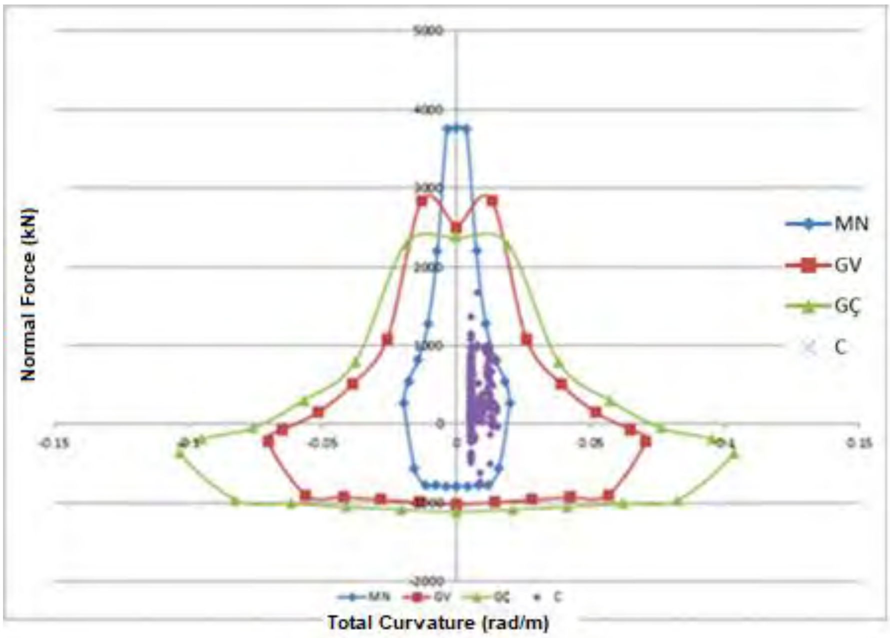


Figure 3.39 Y Direction Time History Analysis Column Assessment Results (Retrofitted Building-Existing Columns-Design Earthquake)

3.4.5.2. Assessment results of 3 storey building beams without shear walls retrofitted using MaSTER FRAME® with time history analysis method (TH)

The tables of the evaluation of the beams prepared according to the results of time history analysis of the 4 storey structure with shear walls and retrofitted using MaSTER FRAME® are given in, **ATT-B-III-2** .

Because beams that appear in the tables with significant damage will not have a negative impact on the building behavior, their damage is ignored. It should be kept in mind that reinforcement of support regions of the beams of existing buildings are just assumption. There is no technology to determine exact reinforcement the support regions of the beams at the moment without sewere damage to the beams. That is why reinforcement about minimum is assumed for this study as it is general application for existing buildings.

Summary table of performance evaluation with time history analysis for 3 storey building without shear walls and retrofitted using MaSTER FRAME® (for Design Earthquake)

It was shown with nonlinear fixed first mode pushover analysis method in previous sections of this report that, 3 storey building without shear walls retrofitted using MaSTER FRAME®, satisfied the conditions of minimum performance level under the effect of design earthquake and life safety performance level under the effect of maximum considered earthquake. Performance analysis with nonlinear time history method was performed to 4 storey building in this section in order to confirm the pushover analysis. Analysis results are summarized in Table 3.26. Because earthquake acceleration records were applied two-way both X and Y direction, element results in the summary table are given for both direction. All columns and shear walls were found to be at minimum damage level. A small amount of beams, in the significant damage zone will make a positive contribution by increasing the overall damping of the structure. It should be kept in mind that reinforcement of support regions of the beams of existing buildings are just assumption. There is no technology to determine exact reinforcement of that regions of the beams at the moment without sewere damage to the beam. That is why a reinforcement about minimum is assumed at it is applied for existing buildings to be assessed in general. Calculated results should be evaluated accordingly.

Table 3.26 Summary table of performance evaluation with time history analysis of 3 storey building without shear walls and retrofitted using MaSTER FRAME® for X and Y direction

3-STOREY BUILDING RETROFITTED BY MaSTER FRAME® / Time History									
	COLUMN			BEAM			--		
	Min Damage	Marked Damage	Advanced Damage	Min Damage	Marked Damage	Advanced Damage	--	--	--
2nd storey	48/48	--	--	80/82	2/82	--	--	--	--
1st storey	48/48	--	--	59/82	23/82	--	--	--	--
Ground Floor	48/48	--	--	54/82	28/82	--	--	--	--

4. CONCLUSSIONS

As a result, two of our typical school buildings were used for retrofitting without stopping the operation of our buildings / schools (appropriate for the technique), using MaSTER FRAME ® technique and MaSTER Disk-Anchor ®.
Selected buildings types are tried to be the most commonly used school types in order to represent wide range of possible school structures. One of them is 4-storey with shear walls and the other one is 3-storey without shear walls, frame type structures. It is paid attention to have apropriate material quality for MaSTER FRAME® technique and MaSTER Disk-Ankraj®' application. Maeda has tested down to C8 concrete quality. However, C15 concrete quality and STIII reinforcement type is preferred in order not to have any other problem causing to enter the building.

Performance analysis for both structures with nonlinear fixed first mode pushover analysis method and It is determined that the structures do not provide the required performance according to the DBYBHY 2007 criteria and retrofitting is required. 4-storey structure with shear walls do not meet criteria in both X and Y direction. Frame type 3-storey structure is found to be sufficient in short Y direction of the structure and the long X direction was found to be insufficient.
MaSTER FRAME® frames and MaSTER Disk-Ankraj® have been applied for retrofitting purpose from outside of the structure in the long X direction for both structures.
Both of the retrofitted buildings have been evaluated using nonlinear firstly fixed first mode pushover performance analysis method. Then, nonlinear time history analysis method was used for performance analysis with selected and scaled 7 earthquakes. For both structures, pushover analysis and time history analysis results were found to be compatible with each other and retrofitted structures using MaSTER FRAME ® and Disk Anchors were determined to meet the conditions of DBYBHY 2007 for Immediate damage performance level under the effect of design earthquake and life safety performance level under the effect of maximum considered earthquake.

As a result of this study, because no need to enter the retrofitted building for MaSTER FRAME® application and low noise level of MaSTER Disk-Anchor® application, it is possible to retrofit the building without interrupting the usage with taking necessary safety measurements. It is determined that MaSTER FRAME® retrofitting technique with MaSTER Disk-Anchor® can be a fast and cost-effective alternative with 3-4 months application duration for appropriate buildings.