第2部　業務完了総合報告書（短期専門家）

和文要約
Final Report（英文）
（別冊）Final Report-Appendix

カンボジア国
公共事業運輸省

カンボジア国

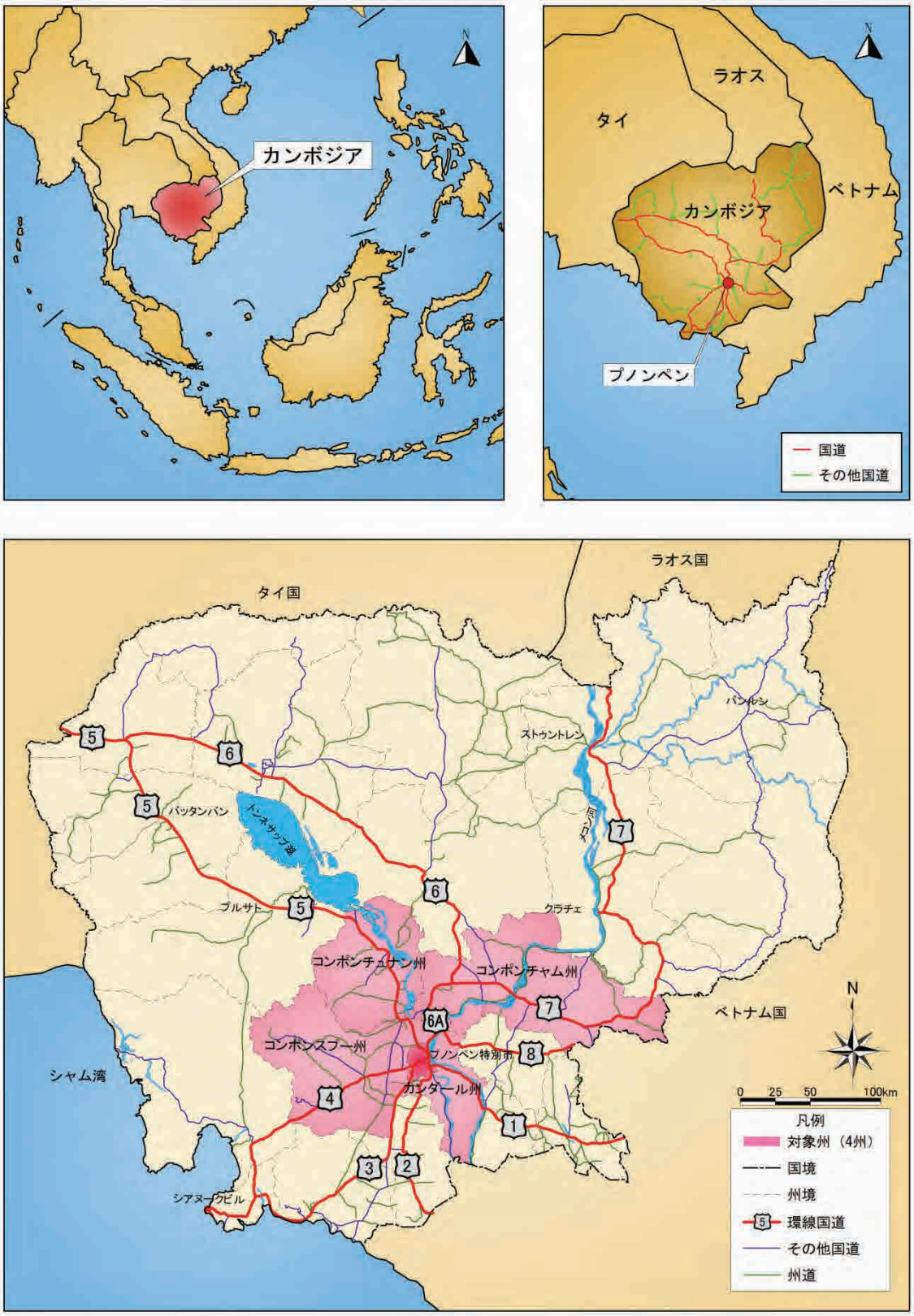
建設の品質管理強化プロジェクト
（道路橋梁建設・維持管理指導業務）

業務完了総合報告書（F/R）
和文要約

平成 24 年 10 月
（2012 年）

独立行政法人
国際協力機構（JICA）

株式会社 片平エンジニアリング・インターナショナル


カンボジア
ラオス
タイ
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ベトナム国
シャム湾
バッタンバン
トンレサップ湖
ストゥントレン
メコン川
ブルサト
クラチェ
コンポンチュナン州
コンポンチャム州
コンポンスプー州
プノンペン特別市
カンダール州
シアヌークビル
N
0 25 50 100km
凡例
対象州（4州）
国境
州境
環線国道
その他国道
州道

業務対象地域図

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1. プロジェクト概要

1.1 プロジェクトの背景

カンボジア国（以下「カ」国）公共事業運輸省(MPWT)は、これまで多くのドナー支援を受けつつ道路や橋梁等の運輸交通インフラ整備・改修に取り組んできた。このうち、我が国を含む各国ドナー支援による道路・橋梁整備は、施工管理のためのコンサルタントや請負事業者らによる品質管理がなされている一方、自国予算により、MPWT 内の道路インフラ部(RID)、重機センター(HEC)や MPWT の出先機関として各州に設置されている公共事業運輸局(DPWT)が直営で実施する道路・橋梁の建設や維持管理においては、予算執行管理上の検査が一部行われるのみで、建設資材の規格確認や施工方法の検査等 建設の品質管理が充分なされていないのが実情である。このため、雨期経過後のポットホール発生など、施工後短期間で道路損傷につながっている。

こうした実情を鑑み、建設の品質管理能力を強化することにより、道路や橋梁といったインフラを完成後も長持ちさせ、同時に維持管理コストの削減を達成することは、国家予算や援助資金の有効活用の観点からも、「カ」国にとって緊急の課題になっている。そこで国際協力機構 (JICA) は、持続的に使用可能な道路・橋梁を建設し補修していくためには、建設の品質管理のための抜本的な体制強化が必要との観点から、「カ」国から要請された建設の品質管理強化プロジェクト（本プロジェクト）を実施することとした。

尚、本プロジェクトは、MPWT における最初の技術協力プロジェクト(TCP)であり、MPWT が自らのオーナーシップを発現し、JICA 専門家と共にプロジェクト目標を達成することが求められている。

1.2 業務内容

(1) プロジェクト体制

- プロジェクト名称：「カ」国建設の品質管理強化プロジェクト
- 実施期間： 2009 年 11 月 27 日～2012 年 10 月 31 日
- 相手国実施機関：MPWT
- 主な支援対象部署:MPWT の公共事業研究センター(PWRC)・RID・HEC・業務検査部(GID)及び 4 州（コンポンチャム、カンダール、コンポンチュナム、コンポンスプー）の DPWT、RID 橋梁班
- 作業フロー：図 1-1 参照 (次頁)

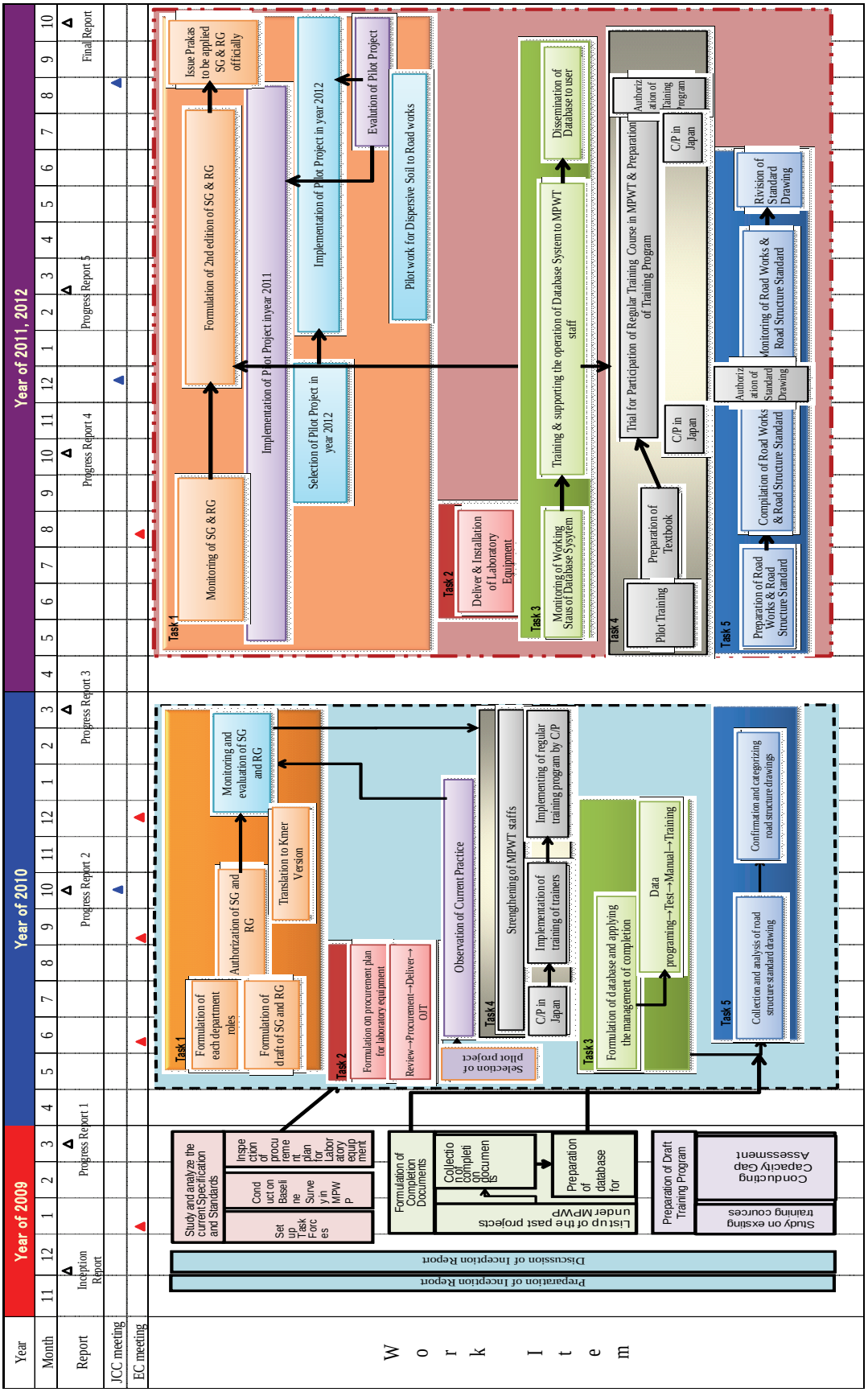


図 1-1 プロジェクト作業フロー

(2) プロジェクトの内容

【上位目標】

MPWT が、直営で実施する道路・橋梁の建設・維持管理の品質が向上する。

【プロジェクト目標】

プロジェクトが構築する品質管理・保証システム（基準・取扱要領と実施規定）の適用によって、MPWT が直営で実施する道路・橋梁工事の品質管理に関する能力が向上する。

【アウトプット】

タスク 1 (Output 1-1) : 道路・橋梁建設の品質管理に係る基準・取扱要領(SG)と実施規定(RG)が整備・適用される。

タスク 2 (Output 1-2) : MPWT 試験所の試験機器が改善され、職員の能力が向上する。

タスク 3 (Output 2) : 完成図書（契約図書、図面、報告書等）の統合集中管理のためのシステムが構築される。

タスク 4 (Output 3-1) : 建設の品質管理向上のために必要な MPWT 内の人材育成体制が強化される。

タスク 5 (Output 3-2) : 道路及び道路構造物標準図集が編纂される。

(3) 各タスクの成果

各タスクの成果を達成するため、プロジェクト・デザイン・マトリックス(PDM)を基に活動計画表(PO)を作成し、各月のプロジェクト進捗をモニタリングし、円滑な活動を促した。JICA 中間評価ミッションでの指摘を受け、プロジェクト目標やアウトプット 1 の指標の曖昧さを是正し、以下のようにタスクごとに実のある成果を達成することができた。

成　果	主な活動	達成された成果
タスク 1 (Output 1-1) 道路・橋梁建設の品質管理に係る基準・取扱要領と実施規定が整備・適用される。	➢ SG と RG を整備し、MPWT 内で正式に適用できるようにする。 ➢ パイロット・プロジェクトを通じ、SG と RG の実施状況を確認する。 ➢ パイロット工事を通じ、分散性土の工事への適用を検討する。	➢ 第 2 版 SG と RG（英語及びクメール語）（JCC で承認） ➢ SG / RG 及び標準図集を適用する主旨の Prakas（省通達）の発令 ➢ パイロット・プロジェクトの評価 ➢ 分散性土適用に関する提言
タスク 2 (Output 1.2) MPWT 試験所の試験機器が改善され、職員の能力が向上する。	➢ 試験所に納入する機器の検討 ➢ 必要機器の据え付けと使用方法の研修	➢ 試験所機器の納入 ➢ 機器の使用についての研修
タスク 3 (Output 2) 完成図書（契約図書、図面、報告書等）の統合集中管理のためのシステムが構築される。	➢ 竣工図書データベースシステムを構築する。 ➢ システムの維持のため図書室内の責任と職務を定める。 ➢ システムを広くユーザーに説明する。 ➢ 操作マニュアルを作成する。	➢ 竣工図書、標準図集及び文献資料についてデータベースシステムを構築 ➢ 竣工図書の収集システム確立

成　果	主な活動	達成された成果
タスク４(Output 3-1) 建設の品質管理向上のために必要なMPWT内の人材育成体制が強化される。	➢ MPWT 定期講習会の内容等をレビューする。 ➢ 講師講習会を実施する。 ➢ 品質管理に係る研修プログラムを作成する。 ➢ 24 州においてワークショップを開催し、SG/RG 等本プロジェクトの成果を広める。	➢ 講師講習会の実施（2 回） ➢ 研修プログラムを作成（JCC で承認）し、MPWT 定期講習会に参加 ➢ 24 州へのワークショップの実施
タスク５(Output 3-2) 道路及び道路構造物標準図集が編纂される。	➢ 過去の竣工図面を収集する。 ➢ 標準図集を作成する。 ➢ 標準図集の活用のため、24 州へ広める活動をする。	➢ 標準図集の編纂（JCC で承認） ➢ 24 州へのワークショップの実施

(4) 専門家及びカウンターパート投入実績

本プロジェクトを円滑に実施するため、表 1-1 のとおりタスク別に JICA 専門家とカウンターパートを組み合わせ、技術移転を行いながら様々な成果を達成した。

表 1-1 プロジェクトメンバー

タスク(Output)	プロジェクトメンバー	
	カウンターパート	JICA 専門家
プロジェクト管理	H.E. Kem Borey(GDPW) Mr. Koun Bunthoeun (PWRC) Dr. Khun Sokha (PWRC) Mr. Samrangdy Namo (PWRC)	山内将史（総括/道路工事契約・積算システム） 弓田和男（副総括/品質管理）
タスク１(Output 1-1)	Mr. Chao Sopheak Phibal (RID) Mr. Kry Thong (HEC) Mr. Sok Pounnaraiy (AID) Mr. Uy Sophal (GDI) Mr. Hum Vuthy (RID) Mr. Laing Onit (RID) Mr. Sang Sinaveth (PWRC) Mr. Phim Phirun (GDI)	山内将史（総括/道路工事契約・積算システム） 野田善久（舗装） 中村友彦（土構造設計） 岡本洋一（試験施工）
タスク１（パイロット・プロジェクト）	Mr. Nou Rethy (PWRC) Mr. Bou Veasna (PWRC) Mr. Pou Manith (RID) Mr. Ros Sreng (RID) Mr. Leng Song (RID)	山内将史（総括/道路工事契約・積算システム） 野田善久（舗装） 中村友彦（土構造設計） 前田辰朗（道路工事施工管理） 井澤衞（橋梁/道路構造物維持管理）
タスク２(Output 1-2)	Mr. Meng Leang	前田辰朗（材料/現場試験、機器管理）
タスク３(Output 2)	Mr. Ky Soklay (PWRC) Mr. Phy Ratha (PWRC)	矢代修一（竣工図書管理システム） 弓田和男（副総括/品質管理）
タスク４(Output 3-1)	Mr. You Dara (RID) Mr. Kry Thong (HEC) Mr. Laing Onit (RID) Mr. Nin Menakak (RID) Mr. Theng Socheat (PWRC)	櫻井裁之（研修/人材育成） 弓田和男（副総括/品質管理）
タスク５(Output 3-2)	Mr. Uy Sophal (GDI) Mr. Kry Thong (HEC) Mr. Hum Vuthy (RID) Mr. Khun Soth (PWRC)	井澤衞（橋梁/道路構造物維持管理） 中村友彦（土構造設計）

2. タスク 1-1 基準・取扱要領、実施規程の策定

2.1 基準・取扱要領、実施規程の必要性

カンボジア国（以下「カ」国）の自国予算により、公共事業運輸省(MPWT)内の道路インフラ部（RID）、重機センター（HEC）や MPWT の出先機関として各州に設置されている公共事業運輸局（DPWT）が直営で実施する道路・橋梁の建設では品質管理が適切に行われておらず、建設資材の規格確認や施工方法の検査等が実施されていないのが実情である。

実情を把握し改善案を策定するために、本プロジェクト着手時 (2009 年 12 月) MPWT のベースライン調査を実施した。下記の関係者に聞き取りし、関係機関の①計画、②基本設計での設計、積算、③詳細設計での測量、設計、積算、設計照査・承認、④実施段階での施工監理、品質管理、工程管理、現場管理、試験、検査、及び各段階での関係機関の役割と責務を確認した。

表 2-1 聞き取り調査をした関係者

1. 総務総局総局長
2. 業務検査部 (GDI) 局員
3. 内部監査局 (DIA) 局長
4. 道路インフラ部 (RID) 局長
5. 重機センター (HEC) 局長
6. 公共事業研究センター (PWRC) 局長
7. 空港建設局 (ACD) 局長
8. カンダール州 公共事業運輸局（DPWT）局長
9. 公共事業試験所 (PWL)局長

表 2-2 入手した基準のリスト

基準・取扱要領		使用頻度	
		頻繁	時々
特定した基準			
1	道路法 (未承認)	DIA	HEC
2	道路設計基準 パート 1, 2 & 3	PWRC DPWT	RID HEC
3	橋梁設計基準	PWRC DIA	RID HEC
4	標準交通制御装置	PWRC DIA	RID HEC
5	建設仕様書 (2003)	PWRC PWL	RID HEC
6	定期維持管理ガイドライン (2008)	DPWT DIA	RID GDI
7	道路補修工事ガイドライン (2008)	DPWT DIA	RID HEC GDI
8	定期検査ガイドライン (2008)	DPWT DIA	RID HEC GDI
9	定期維持管理ガイドライン (2008)	DIA	RID HEC
10	施工者能力評価書式 (2008)		RID GDI
その他の基準			
11	道路及び構造物の維持管理の材料仕様抜粋	RID	
12	公共工事のために技術基準の基本	HEC RID DPWT	

2.2 基準・取扱要領と実施規程第一版の作成・承認

2010 年 1 月のカウンターパートミーティングでタスク 1 のカウンターパートが決定された。

さらに 2010 年予算 Chapter21（新規、改修工事／首相承認）と Chpter61（維持管理工事、緊急工事／大臣承認）の承認プロジェクトリストや MPWT の各部局の役割、責務を明記した業務分掌を入手し、分析を行った上で、実施の流れを確認した。また、その流れの中で問題点を特定し、改善策を基準・取扱要領(SG)、実施規程(RG)に反映する方針とした。

表 2-3 直営工事の問題点とその対策方針

		問題点	対策方針	
			基準・取扱要領	実施規程
計画段階	7 月～12 月	基本設計は決められた一断面を使用。調査は実施していない。	地形（湿地、平地、山岳地）により 3 種類の断面選択する方法を提案。	関係者を分類し、それぞれの役割・責務を明確化 (図 2-1 参照)。 契約書の書式を標準化。
実施段階	1 月～12 月	詳細設計で調査不十分。	調査項目及び方法、立会者を提案。	
		設計は基本設計の断面を使用。	CBR 値、軸重値を元に一覧表から断面を決定する方法を提案。	
		監理者がいない。	監理者確保を提案。	
		品質管理が実施されていない。	管理項目、書式、整理方法、保管方法を提案。	

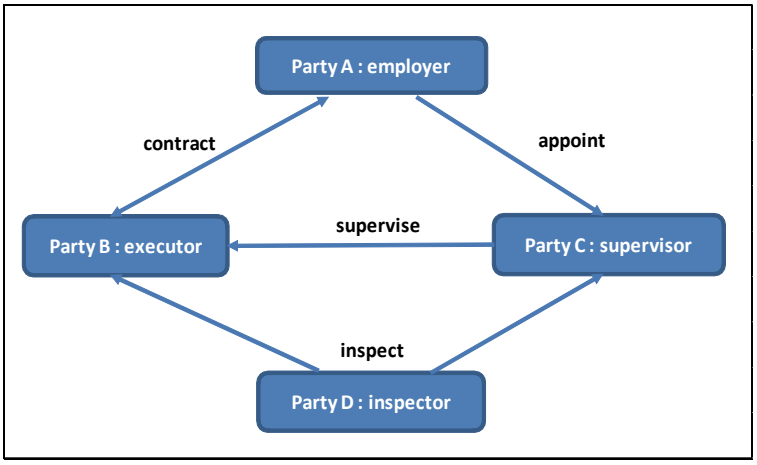


図 2-1 建設中の関係部局の関係

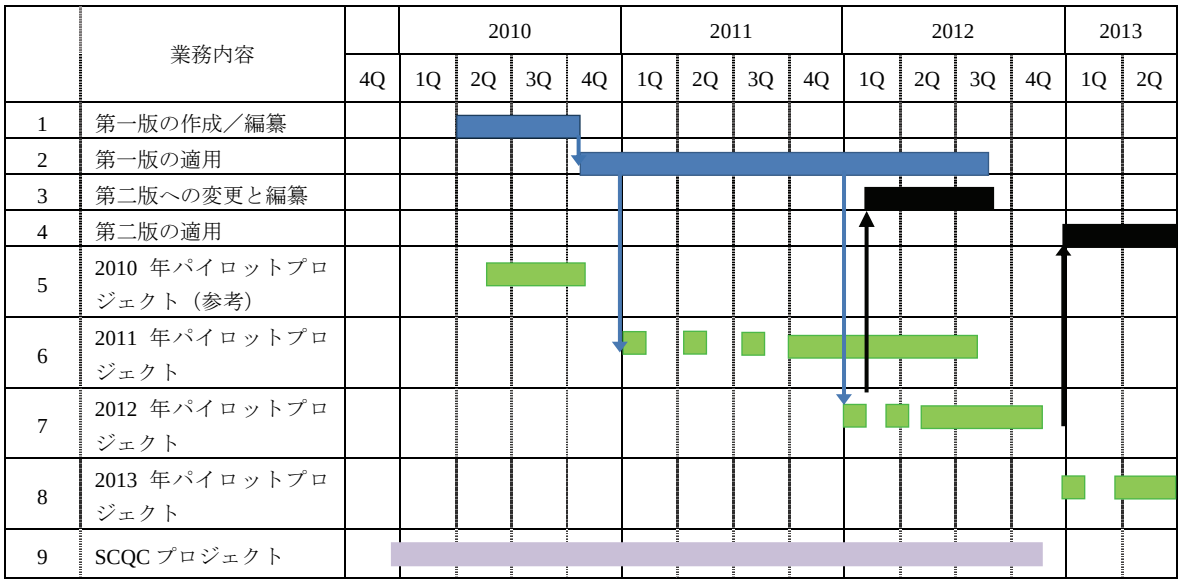
- 上記方針を元にして SG / RG の目次案を作成し、2010 年 2 月のカウンターパートミーティングで作成した目次案を説明。
- 2010 年 3 月～4 月、カウンターパートの分担を決め、執筆作業。
- 2010 年 5 月、専門家とカウンターパートが協議し執筆内容を確認。
- 2010 年 6 月～8 月初旬にかけて HEC、RID 及び DPWT に説明し、37 項目のコメントを受領。これらについて協議・修正し、英語・クメール語版を作成。

・ 2010 年 8 月 27 日 MPWT と 24 州の DPWT に対しセミナー実施。
・ 2010 年 9 月 1 日 運営委員会(EC)で承認。
・ 2010 年 10 月 13 日 合同調整委員会(JCC)で承認。

2.3 パイロット事業の実施

SG / RG の承認を受けて、パイロットとして適切な案件を 2011 年から 2 案件、2012 年から 3 案件選定した。これは、SG / RG の内容の周知徹底と共に実施を通じての教訓を元に必要な更新を行うためである。なお、2010 年の案件は、現状の把握と 2011 年以降のパイロットプロジェクトのベースとして選定した。

表 2-4 基準・取扱要領、実施規定とパイロットプロジェクトの工程



各パイロットプロジェクトに関し、①契約書の周知の程度、②施工計画書・品質管理計画書の作成状況、③品質管理試験の実施と記録の保管状況、④工程表の有無及び管理状況、⑤その他書類(月報・議事録等)の作成状況、について評価を行った。各項目を 5 段階評価 (5 は優、3 は可、1 は不可) し、総合評価(各項目の平均値)を表 2-5 に示した。SG / RG を適用した 2011 年以降に実施したプロジェクトの評価が高くなっている。2012 年のプロジェクトも完成に近付くと共に 2011 年程度の評価になるものと推察される。

表 2-5 パイロットプロジェクト一覧とその評価

予算年	州	道路番号	概要	Party B	Party C	現状	評価
2010	カンダール	118 P-1	5km DBST 橋梁 12 か所	RID 道路橋梁ユニット	RID	完成	2.6
		118 P-2	5km DBST 橋梁 3 か所	カンダール DPWT	RID	完成	2.3
		118 P-3	5km DBST 橋梁 7 か所	HEC	PWRC	完成	2.5
	コンポンチャム	7	2.8km DBST 7 区間	コンポンチャム DPWT	RID	完成	2.6

予算年	州	道路番号	概要	Party B	Party C	現状	評価
2011	コンポンチャム	71	2.5km DBST 3 区間	コンポンチャム DPWT	RID	完成	4.1
	カンダール	110	3.0km DBST	カンダール DPWT	PWRC	進捗 70%	3.7
2012	コンポンスプー	44	6.0km DBST	コンポンスプーDPWT	RID	進捗 20%で中止	2.8
	コンポンチャナン	153	3.0km DBST	コンポンチャナン DPWT	PWRC	進捗 10%	2.9
	コンポンチャナン	11	橋梁 1 か所 (15m＋15m)	RID 橋梁ユニット	RID	進捗 50%	3.3

2.4 基準・取扱要領と実施規程第二版の作成、承認

パイロット事業の実施を通じた教訓を元に、表 2-6 の通り基準・取扱要領、実施規程の内容を加筆・修正・更新し、第二版として 2012 年 8 月 30 日の JCC で承認された。基準・取扱要領及び実施規程の最終的な内容は表 2-7 及び表 2-8 の通りである。

表 2-6 第二版で加筆、修正・更新、追記した箇所

基準、取扱い要領	・杭に関する本文、付録の追加 ・チェックリストの追加 ・書式の使用上の注意を追記 ・軸荷重検査の参照先を明記 ・関連組織名更新
実施規程	・プロジェクト情報に関する文章追記 ・契約書式の修正 ・関連組織名の更新

表 2-7 基準・取扱要領（第二版）の内容

第一章	一般	第八章	詳細調査と測量
第二章	維持管理に関係する関係局の責任	第九章	詳細設計
		第十章	詳細積算
第三章	基本測量と調査	第十一章	品質管理 (1.土工事 2.舗装工事 3. 杭工事(追加) 4.コンクリート工事)
第四章	基本設計		
第五章	概略積算		
第六章	上限値の決定	第十二章	検査
第七章	特別前途金	第十三章	実施機関の検査
付録	A 出来形検査記録（杭工事追加）B 砂置換法による現場密度試験方法と書式 C プルーフローリング記録書式 D アスファルト材敷設のチェックシート E 土工事品質管理書式 F 杭工事品質管理書式（追加）G コンクリート工事品質管理書式（杭工事追加）H チェックリスト（追加）I 検査依頼		

表 2-8 実施規程（第二版）の内容

第一章　一般条項	1.範囲、2.目的、3.適用範囲、4.直営工事の関係部局の役割と責任
第二章 関係組織の規則	1.基本設計･調査、2.概略積算、3.契約交渉、4.予算確定、5.詳細調査、6.詳細設計･積算、7.最終契約交渉、8.契約、9.実施、10.プロジェクトの評価
付録	1.Party A と Party B の契約書の書式、2.プロジェクト情報

3. タスク 1-2 分散性土の道路工事への適用検討

3.1 背景

「カ」国の洪水域には分散性土が分布している。分散性土は降雨や洪水により分散・浸食され、「カ」国で“ドラゴンホール”と呼ばれる穴を作る性質がある。分散性土は、これまでその分散性を確認することなく道路工事の盛土材として使用されてきた。そのため、分散性土を使用した道路盛土や法面は崩壊し、繰り返し復旧する必要があった。

このような背景から、高品質の道路構造物を確保するためには、土工事において分散性土を適切に取り扱うことが期待されてきた。

一般的に、分散性土はカルシウムイオンを含むセメントや石灰を混合することで、水に対して安定すると言われている。本検討では、現地の技術者が簡易に分散性土を見分ける事が可能な簡易分散性試験を採用し、原法面土および添加材（セメント等）混合土の室内簡易分散性試験、および室内試験の結果を基に既存道路法面改良の試験工事を実施したものである。

3.2 室内試験

試験工事現場からサンプル土（原法面土）を採取し、簡易分散性試験を実施した。分散性の程度を「無」、「小」、「中」、「大」の 4 段階で評価した結果、75 のサンプルの内 92%は分散性があると判定された。内訳は、「無」：6 サンプル、「小」：14 サンプル、「中」：8 サンプル、「大」：47 サンプルであった。

また、分散性があると判断されたサンプル土に添加材（セメント、石灰、石膏、フライアッシュのそれぞれ 1/3/5/7%）を混合した土（供試体）を試験した結果は次の通りであった。

- ◆ 原法面土の分散性の程度が「小」、「中」の土に 1%以上のセメントもしくは、石灰、石膏を添加した供試体は分散性が「無」であった。
- ◆ 原法面土の分散性の程度が「大」の土に 3%以上のセメントもしくは、石灰、石膏を添加した供試体は分散性が「無」であった。1%のセメントでは、「小」となった。
- ◆ フライアッシュは、分散性を悪化させる結果となった。

以上より、セメントおよび石灰、石膏は、1～3%の添加量で分散性を防止する作用がある事が分かった。

3.3 試験工事

試験工事は、プノンペンから約 20km 離れた国道 21 号の道路法面（延長 240m）にて実施した。試験工事の目的は、室内試験にて分散性が認められた既存道路法面土に添加材を混合・改良し、分散性に対して安定させる施工方法を見出す事であった。工事は延長 240m の区間を 10m 毎の 24 区間に分け、それぞれの区間の施工条件を変えて実施した。施工条件は次の通りである。

添加材種 : セメントまたは石灰（改良効果の無いフライアッシュと価格の高い石膏は除いた。）

添加材混合率：1.0 または 1.5、2.0、2.5、3.0、3.5、4.0、4.5、5.0、5.5、6.0 %

添加材混合後の施工までの放置時間：0.5 日または 3 日

混合時間：1.7 分/m^3 または 3.3 分/m^3

改良厚：0.5m または 1.0m

3.4 工事後の踏査結果

工事完了後、約 3 ヶ月間の雨季を含む約 5 ヶ月経過した後に、施工した道路法面の状況を確認し、試験工事の効果を評価した。現場踏査の結果、法面にはいくらかのドラゴンホール（電柱周りの未改良部分および特定の改良部分に発生）や全区間の法面にガリー浸食（法表面に覆土した未改良の植生土に発生）が確認された。これらの状況を各区間の施工条件と照らし合わせ、以下の事が分かった。

- 添加材種（セメントまたは石灰）による改良効果の違いは無かったが、セメントは石灰よりも安価であるため、添加材としてセメントを推奨する。
- 添加材混合後、施工までの放置時間（0.5 日または 3 日）による改良効果の違いは無かった。
- 改良厚（0.5m または 1.0m）による改良効果の違いは無かった。

ドラゴンホールが 1 つでも発生した区間は「改良効果が認められない」区間とし、「改良効果が認められる」区間の割合（改良効果率）を施工条件毎に整理したところ以下の結果を得た。

- 添加材混合率が 2.5%以上で混合時間が 3.3 分/m^3 以上の場合、改良効果率は 100%
- 添加材混合率が 2.0%以上で混合時間が 1.7 分/m^3 以上の場合、改良効果率は 95%
- 添加材混合率が 1.0%以上で混合時間が 3.3 分/m^3 以上の場合、改良効果率は 88%

以上より、改良効果は混合時間よりも添加材混合率に依存する事が分かった。

3.5 評価

前記の踏査は、約 3 ヶ月間の雨季の経過後に実施された。道路法面が今後さらに降雨や洪水を受けた場合にどの様に変状するかを見極めた後、最終評価をすべきであると考える。また、本改良工事では土と添加材の混合を入手しやすいバックホーにより実施したが、より混合効率の良い機材、例えば混合プラント等の導入を検討する事が必要であろう。さらに、セメント混合の価格、良質土を調達した場合の費用、混合方法等を総合的に検討することにより、経済性および品質を確保した工事の実施が可能となる。

本検討では、上記の検討課題はあるもののセメントによる改良により、分散性土を盛土工事に適用できる事が確認できた。盛土工事に適用する際の留意点は以下の通りである。

- 施工前に対象土の簡易分散性試験を実施し、分散性の有無、程度を確認する事。
- 良質土の調達とセメントの添加による改良とのコスト比較をする事。
- 改良効果の高い施工条件は、以下の通り。

  添加材：セメント

  混合率：2.5%以上

  混合時間：3.3 分/m^3 （混合機械：バックホー　0.4-0.6 m^3 使用の場合）

4. タスク 1-3 道路台帳の予備的検討

4.1 背景

公共事業運輸省(MPWT)は、多くのドナーの支援を受けつつもこれまで道路整備や維持管理事業を通じ、国の道路管理者として経済発展に寄与してきた。自国予算の事業については、新設工事を重機センター(HEC)、また道路維持管理工事を道路インフラ部(RID)が担い、年々増加する予算を使い、インフラ整備を行ってきた。しかしながら、ドナー援助も含めた道路整備事業全体の管理、すなわち、いつ、誰が工事を完成させ、現在どのような状態になっているかは、MPWT の各部局が独自の責任とルールに則り実施しているが、省全体で決まった担当部局が把握しているという状況にはなっていない。

こうした状況の中、RID は道路の定期点検として半年に 1 度、道路インベントリーを公共事業運輸局(DPWT)や RID 職員の目視点検を中心に実施している。その点検は、2008 年 JICA 専門家の協力で作成したガイドライン（Guideline for Regular Inspection）に基づいて実施され、ガイドラインに参考様式としてあるインベントリー・シートに点検結果を書き込み、道路状況の把握を行っている。

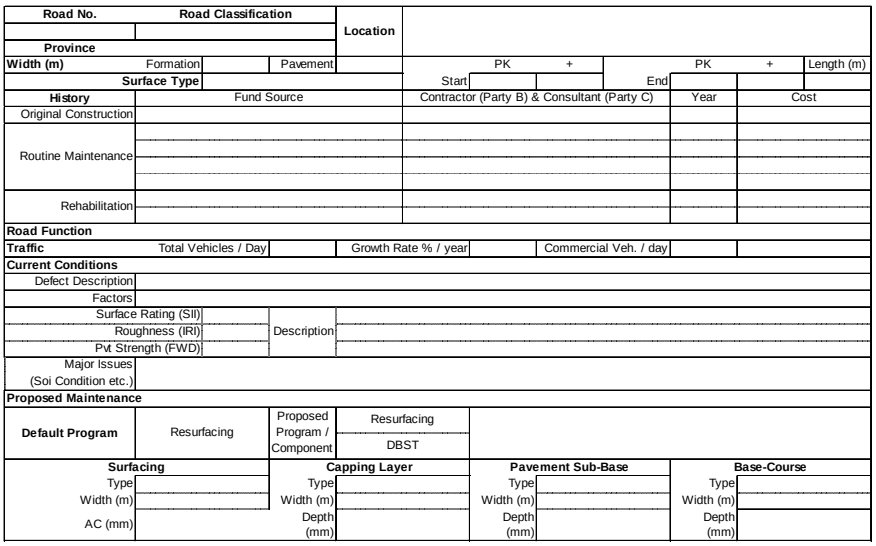
一方で 2004 年、世界銀行(WB)の援助で実施された車に搭載された機器等により道路状況を確認する調査、LRCS（Location Referencing and Condition Survey）が実施された。しかしながら MPWT における予算の関係もあり、このデータを更新するには至らず、最近 WB を中心としたドナーの援助による道路アセット管理プロジェクト(RAMP)の 1 つのコンポーネントとして、LRCS の更新が予定されている。今回の LRCS では RMDS（Road Management and Decision Support System）と呼ばれるソフトを使い、道路状況のみならず、図面とカメラで道路の損傷位置と状態を確認し、データを集積することができるという先進的なインベントリーを実施することになっている。

これら二方向からのインベントリー調査は、道路状況の把握を主眼においており、次年度の予算作成の根拠として使われることになり、優先順位等により工事を選別することが可能となり、よい効果をもたらすものと思われる。

しかしながら先に述べたように、これらで得られた情報を蓄積し、持続的に管理するためにも道路工事のデータベースの構築は必要であり、道路インベントリーの基礎となるデータ、すなわち、新設・維持工事をいつ、どこの資金で実施したかを把握する必要がある。そこで本プロジェクトが作成したデータベース（竣工図書の整理）を利用し、各路線の工事情報をデータベース化することで個別路線の工事履歴を把握することが可能となり、各路線の寿命や道路の損傷の原因を究明するのに役立つものとして、次のような提案を行う。

4.2 道路データ履歴台帳の作成

本プロジェクトでの成果の一つであるデータベースシステムは、竣工図書を収納し、今後の道路事業に役立てるために構築された。過去の竣工図書は収集を続けていかなければならないが、むしろこれからのプロジェクトの情報集積がより持続的な履歴台帳作成には必要となる。

<table>
<tr><td>目　的</td><td>• 竣工路線の新設工事を情報の基礎として、本プロジェクトのシステムに集積し、その後実施される維持管理事業の履歴を入力することで各路線の寿命を把握する。
• 損傷の早い箇所（路線）を把握することが可能となり、その路線の根本的な原因を究明する。
• 当初工事について、いつ、どの資金で、どこの施工会社が実施したプロジェクトか把握し、将来の整備計画の参考にする。</td></tr>
<tr><td>収集方法</td><td>• 本プロジェクトで提案され、現在実施中である各工事の情報(Project Information)を提出させ、データベースシステムに入力する。</td></tr>
<tr><td>担当部署</td><td>• 公共事業研究センター(PWRC)が収集し、図書室で管理する。</td></tr>
<tr><td>検索方法</td><td>• 検索システムを作成し、MPWT 内で検索できるようにする。
例えば、道路別、橋梁別、州別、資金ソース別、年度別等。</td></tr>
<tr><td>アウトプット
・イメージ</td><td>• 想定している画面上のアウトプットは以下の通りであるが、よりわかりやすい様式にするために更に検討が必要である。
 
</td></tr>
</table>

4.3 道路インベントリーに係る今後の協力について

4.1 でも指摘したように、MPWT 内に道路インベントリーを管理する部署が存在していないことが最大の課題であるが、今後道路インベントリーに係る協力をするにあたり提言を以下にまとめた。

1) 道路・橋梁履歴台帳の作成のため、データベースの構築をする。
2) 基礎データを収集するために、現在図書室に収納されている竣工図書からできる限り Project Information を作成し、このデータベースにインプットする。
3) RID の定期検査データを共有し、データベースにインプットし、履歴や現状がわかりやすいアウトプットの様式を作成する。
4) 各インフラ事業の部署が情報を共有し、道路インベントリー担当部署を決め、その職務と責任を明確にし、持続的な更新ができる現実的な仕組みを作成する。
5) 各国ドナーに道路・橋梁履歴台帳への協力を求める。
6) RAMP のシステムと融合できるか検討する。

5. タスク 2 MPWT 試験所の機材の改良

5.1 試験所活動と試験所職員能力の実情

試験所は三部門(総務部、経理部、技術部)からなり、技術部はさらに四室(土質、建設材料、道路、顧客)に分かれ、総勢 29 人の組織 (2010 年 1 月時点)である。
業務の種別 (発注者別・作業別) は以下の表の通りである。

表 5-1 発注者別・作業別業務数 (2010 年 1 月-5 月の業務実績)

発注者	公共工事			民間工事	合計
	MPWT	他省庁	建設会社		
業務数	１４	８４	２８１	４７	４２６

作　業	道路工事	建築工事	その他工事	合計
業務数	３９７	7	４４	４４８

2010 年前半の実績によれば、公共工事が約 90%、道路工事に係る業務が同じく 90%を占めている。作業内容は材料試験（土、砕石、アスファルト、コンクリート）から現地調査まで多岐に亘り、道路に関する試験のほとんどを網羅している。

5.2 供与機材の選定経過

供与機材の選定に当たっては、道路に必要な米国材料試験協会(ASTM)規格の定める米国州道路交通運輸担当官協会(AASHTO）試験に必要な試験機材をリストアップした。同時に、試験所所有の試験機材を調査した。一例として路床に関する AASHTO 試験法を表 5-2 に、試験所所有の動粘度試験器を図 5-1 に示す。

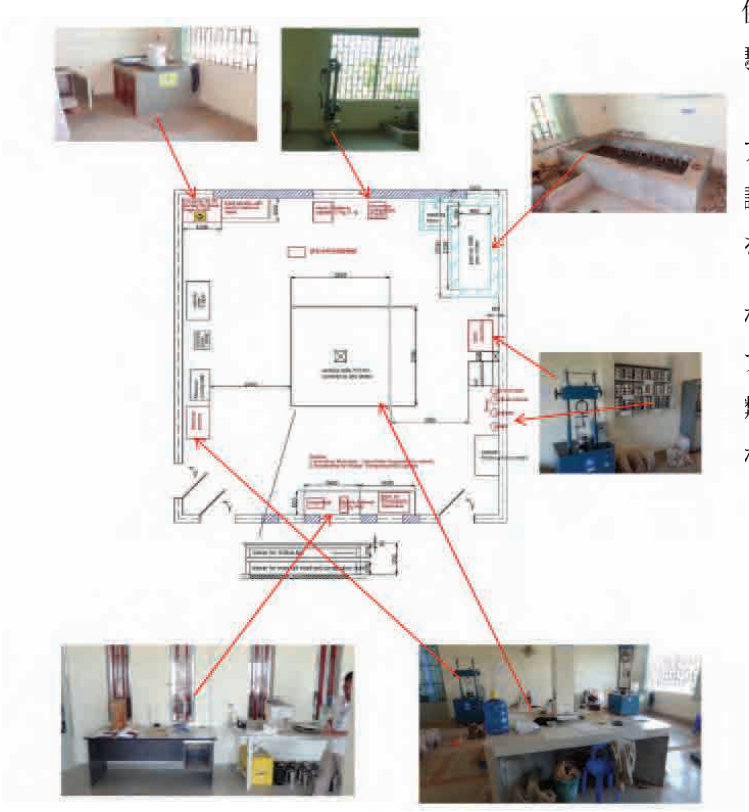
表 5-2 AASHTO 試験法：路床

2 Sub-grade quality	ASSHTO M145	AASHTO
Classification	Test Item	Test method
material	Liquid Limit	T 89
	Plasticity Index	T 90
	Moisture-Density Relations	T 99 or T 180
	Modified CBR	T 193
site	moisture content	T 27,T 93
	Sieve Analysis, maximum size	T 27
	Degree of compaction	T 191
	proof rolling	-

２台所有。但し、破損しており使用できない。

図 5-1 動粘度試験器

5.3 供与後の維持管理状況



供与された試験機材と既存の試験器具を組み合わせ、アスファルト舗装に関する試験を盛土からアスファルト舗装まで一貫して試験可能なアスファルト試験室を設置した。

なお、フルイは、土、砕石、アスファルト舗装、コンクリートに分類し、フルイ目の大きさを混同しないようにした。

5.4 今後の品質管理に必要な機材及び試験所の機能

現在の MPWT 試験所の主な仕事は、外部から依頼される試験であり、積極的に品質管理に寄与する土の採取場、採石場の選定、配合設計（路盤材、アスファルト舗装材、コンクリート）などの仕事は皆無である。今後は品質管理のみならず品質保証の観点から、これら業務への積極的な関与が望まれる。

カンボジアは未だ ISO に未加入ではあるが、試験所は各ドナーより多数贈与された試験機材の検定、周期検査を含め校正機関としての役割も果たす必要がある。また、試験室の仕事は圧倒的に土に関する試験が多い。現在は人力締固め試験器を使用しており、多大な労力を必要とするため試験回数も制限されている。以上の観点から、今後品質管理に必要な機材として、検定用ロードセルや自動締固め試験器を購入することを推奨する。

6. タスク 3 竣工図書の集中管理のためのシステム構築

6.1 システム構築の必要性

《背景》

これまで建設プロジェクトの竣工図書は公共事業運輸省(MPWT)内でまとめて整理されておらず、過去の図書並びに既存資料はプロジェクト担当者が個別に所持しているか、または保管先が不明となっている。また保管図書はハードコピーしかなく、目にできるのはプロジェクト担当者やごく一部の者に限られ、他スタッフや技術者にはそのような竣工図書があることもわからない状況である。

本タスクは、これまでの竣工図書を整理し、それらを「有効に活用すること」により、業務の効率および建設の品質向上を図るよう、建設プロジェクトの竣工図書の集中情報管理システムを確立することである。公共事業研究センター(PWRC)が管理する図書館で電子データを管理、維持し図書の電子化を図る。これらのプロセスが構築されることで、MPWT のスタッフが、過去の資料や既存資料を参照することが可能となり、将来のプロジェクト計画、工事の実施、技術向上に役立てることができる。

《目的》

竣工図書及び技術書の整備を行うことにより、過去の資料や既存資料が有効利用され、業務効率が向上する。これらの資料を逐次電子データファイルとして作成し、データの情報管理を一元化し、データの管理、運用の定着を図るためデータベースシステムを構築する。

6.2 システム構築までの過程と運用方策

システム構築に至る活動内容は以下のとおり。

《基本計画》

(1) データベースの構築
(2) ネットワークの構築
(3) トレーニング及びマニュアルの作成
(4) 必要機材：情報共有するためのサーバー、パソコン、周辺機器およびソフトウェア

《活動》

① 竣工図書の分別：散在していた竣工図書を分別し、データ化する図書のデジタル化準備作業。
② 竣工図面のデータ化：竣工図面（ハードコピー）からソフトコピー変換作業を外部委託。変換に必要な A1 図面と A3 図面を、デジタルカメラを用いて写真撮影の方法でデジタル化した。
③ データベース構築：データベースシステム構築の仕様書を作成し全体のアウトプットの

イメージを確定した。これらをまとめ、業者への入札書類（案）を作成し、竣工図書データベースシステム構築の作業を、現地コンサルタントに業務委託した。

データベースシステム構築会社（現地コンサルタント）と毎週進捗報告会を実施し、作業状況の説明、画面設計やインタフェース設計、システムについて修正点・変更点を議論し、デモンステレーションを実施して不都合な点を解消し、2010 年 11 月システム構築を終了し、調達された機材と共に MPWT に引き渡した。

④ メンテナンス：システム構築後、メンテナンス会社が週 1 回保守管理として MPWT を訪れ、システム状況を確認すると共に、カウンターパートに対して相談窓口となっている。

⑤ データベースマニュアルの更新：竣工図書のデータベースシステムマニュアルとして、図書のスキャニングマニュアルとユーザーマニュアルの更新を行った。

6.3 課題と提言

(1) システム維持管理責任者・実務担当者の明確化

竣工図書を収集し、システム化する作業過程において、責任者と実務者の役割分担を明確にする必要がある。システムはすでに完成していているものの、それぞれの担当者が不明確な状況では、持続的なデーターベースシステムの効果を発現できない。運用上の責任者及び実務担当者を早急に明確にする必要がある。

(2) データベース管理者の訓練

システムを構築した現地コンサルタントをトレーナーとして招き、システム管理者およびオペレータ訓練を実施、独自に更新、保守・管理が行えるよう訓練を行う。

(3) MPWT のトレーニングプログラム

MPWT が実施している人材育成のためのトレーニングプログラムにデータベースシステムの教育を取り込み、システム管理者が講師となり人材育成を図る。

(4) ユーザーに向けて

上記にからみ、トレーニングだけでなく、本システムをより多くのユーザーに向けて発信し、利用率の向上を図る。またユーザーからのフィードバックを受け、システムの改善、機能改良を図るようにすれば、マネジメントシステムがもっと有益になる。

(5) 建設工事として自国資金のプロジェクトとドナープロジェクトの２つがあるが、竣工図書の提出に関しそれぞれ責任者と承認先が異なる。今後、プロジェクトタイプ別に以下のように役割分担することを推奨する。

プロジェクトタイプ	提出責任者	承認先	データ入力・管理者
自己資金プロジェクト	Party B が Party C に提出 承認先に提出	Party A	PWRC が承認先から受理し、PWRC によりデータの入力・保管、管理を行う。
ドナープロジェクト	MPWT(プロジェクト担当) 承認先に提出	PMU	

7. タスク 4 研修プログラム

7.1 公共事業運輸省(MPWT)における研修の実情と職員の能力把握

MPWT は、2005 年より定期研修を実施している。その方法は、MPWT と公共事業運輸局(DPWT)の職員に対しての講義形式で、毎年 4 月から翌年 3 月にかけて各月の最終週の 1 週間を使い実施している。参加者は、中間管理職を含め MPWT・DPWT の各部署から選定される。エンジニアだけでなく、事務職員も含まれており、技術的な項目の他、MPWT の管理側の講義項目も含まれている。

こうした研修制度があり品質管理に係る項目の研修も実施されているが、体系的に具体的な講義というよりも、MPWT の局長以上が MPWT での経験を重視した内容のものが多く、実践で身につけるための講義にはなっていないのが実情である。

こうした実情を踏まえ、体系的な品質管理に係るプログラムを作成するにあたり、MPWT・DPWT 職員の能力把握をするために、まず能力のギャップ調査(CGA)を実施した。CGA では、様々な質問を職員 500 名を対象に実施したが、サンプル数は 59 名に留まった。幸いにして、各階級別（局長レベルから現場代理人レベル）のサンプルを集めることができ、現状についてかなり把握することができた。

7.2 講師教育

MPWT の能力把握を実施後、品質管理に係る研修プログラムの作成に取り掛かるが、肝心の講師は誰にするか、研修教材はどういうものを活用するかについて言及する必要があった。しっかりした講師なくしては、持続的な講義を続け、品質を担保することもできないため、まず講師を育成するための講師トレーニングを実施した(2 回)。その実践の場として、パイロット研修を 2 州（2011 年パイロットプロジェクトの対象州）で実施した。

このパイロット研修の教材には、2010 年 10 月の JCC 会議で承認された基準・取扱要領(SG)と実施規程(RG)を使用し、講師トレーニングを受講した講師が講義を行った。パイロット研修の評価会も行い、来る MPWT 内定期研修への参加につなげていった。

また教材については、SG や RG を始め、既に MPWT で技術図書として活用されている建設仕様書(Construction Specification)等を使用することを提案した。講師トレーニングを終了した計 12 名のカウンターパート職員が定期研修で講師をすることとなっている。

7.3 研修プログラム

こうした現状の把握や講師・教材の活用について、MPWT の人材育成局(Human Resources Department、定期研修のプログラムを作成している部署）と話し合い、2011 年の後半には定期研修に参加することが認められた。

2011 年の実施では、SG と RG や標準図集、データベースの構築等 本プロジェクトでの成果を発表する場になり、体系的な品質管理の講義には至らなかった。それらの反省も踏まえ、2012 年の定期研修では、教材も独自のパワーポイントを作成する等現場で実践できる形に変え、強調すべき点を整理した。その結果、2012 年 8 月に開催された JCC 会議では、SG / RG

等の本プロジェクトの成果だけでなく､建設の品質に係るプログラムを表 7-1 の通り作成し、承認を受けることができた。このプログラムは今後 3 年程度継続し、MPWT･DPWT エンジニアのほぼ全員が受講できることを目指している。

表 7-1 研修プログラム

	講義項目	重点内容	講師	所属	時間
1	1-基準・取扱要領(SG)	1-SG とは、 2-品質管理の記録方法 3-品質管理試験 4-検査	1-You Dara 1-Pou Manith 2-Bou Veasna 2-Kry Thong 2-Phibal 3-Meng Leang 4-Laing Onit	1-RID 1-RID 2-PWRC 2-HEC 2-RID 3-Labo/MPWT 4-RID	5 時間/日
2	1-実施要領(RG) 2-標準図集 3-データベースシステム	1-RG の活用 2-標準図集の活用方法 3-データベースシステムの操作方法	1-Namo 2-Hum Vuthy 2-Kun Soth 2-Menakak 3-Phy Ratha 3-Sok Lay	1-PWRC 2-RID 2-PWRC 2-RID 3-PWRC 3-PWRC	4.5 時間/日
3	1-品質試験法 2-土質について 3-土工事	1-現場密度試験 液性限界 最大乾燥密度 2 締固め試験 土の分類	1-Meng Leang 2-Chea Dara	1-Labo/MPWT 2-RID	5 時間/日
4	1-安全管理 2-道路交通安全	1-工事現場における安全管理	1-Sovicheano 2-Kong Sophal	1-DGD of Public Works 2-DIR,MPWT	5 時間/日
5	1-橋梁工事 2-橋梁維持管理	1-ﾌﾟﾚｽﾄﾚｽﾄｺﾝｸﾘｰﾄ上部工設計手法	1-Yen Sereyvuth 2-Uy Sophal	1-RID 2-GDI,MPWT	5 時間/日
6	1-工事契約 2-道路状況管理システム	1-契約管理 2-道路状況調査システム	1-Namo 2-Tou Samnang 2-Kry Thong	1-PWRC 2-HEC 2-HEC	5 時間/日
7	1-測量 2-GIS マッピング		1-Kun Soth 2-Khun Sokha	1-PWRC 2-PWRC	5 時間/日

7.4 課題と提言

今後品質管理を持続的に実践していく上で重要なことは、定期研修と共に、24 州に直接出向いて DPWT 職員に対してワークショップを継続して実施することである。講義形式は座学だけでなく、各州のモデル現場を訪れ、直接指導という形も考えていくべきであろう。24 州へのワークショップについては、2012 年に実施し、出席者からは今後も継続してほしいという要望を受けており、予算を確保して継続していくことを推奨する。

また、受講した後に各州から講義や SG / RG の内容確認の連絡もあると考えられるので、MPWT 内にそれらの質問に答える窓口を設置することも提言する。ここには現場での課題に対する相談も受ける役割を付与しておきたい。

8. タスク 5 道路及び構造物標準図集の編纂

8.1 標準図集の必要性

公共事業運輸省(MPWT)では、1998 年にオーストラリア政府の援助で設計基準の制定に関する検討を実施している。オーストラリア基準（AUSTROAD　1992）、米国基準（AASHTO）、カナダ基準（Ontario　Highway Bridge Design Code）、ニュージーランド、ロシア、日本、中国の各基準を比較検討して、最終的にオーストラリア基準をベースとしてカンボジア基準を制定した(2003 年)。ただし、各ドナーが実施する橋梁建設において 2003 年以降も本基準に統一することは出来ず、それぞれのドナーが採用する設計基準で橋梁が建設されてきたため相変わらず複数の基準が混在している状況である。直営工事で新橋を計画する場合に各ドナーの竣工図を準用しているが、設計基準がオーストラリア基準ではなく整合性がとれていなかった。そのため、標準図集としてオーストラリア基準との整合性を持った標準図集が必要とされた。

8.2 標準図集作成の進捗と編纂

タスク 3 において収集された竣工図面のカメラ撮影によるデータ化が実施されたが、これら写真データから、道路、パイプカルバート、ボックスカルバート（58 箇所）及び橋梁全般(96 橋)に関する竣工図を収集し、項目別にデータ分析を実施し元データとした。

収集された竣工図は、主に各ドナーによる設計図面であり AASHTO ベースの図面が多かったため、AASHTO より大きなトラック荷重を適用するオーストラリア基準への調整が必要であった。必要な分類化の実施後全て CAD 図面を作成することとした。構造詳細を決めるためタスク 5 のカウンターパート(C/P)を中心にして質疑応答を実施した上で、次官や道路インフラ部(RID)、公共事業研究センター(PWRC)及び重機センター(HEC)の各局長個別に打合せを持ち内容を確認していった。特にカンボジアの特徴（亜熱帯、地震がほとんどない事等）に着目して「カ」国に相応しい標準図集の作成のため経済性・走行性・耐久性に留意してこれまでの竣工図から得られる構造詳細を吟味して選定した。

2010 年 11 月より CAD 図作成に取り掛かり 2011 年 12 月 21 日の JCC 会議で承認を受けた。その間、承認体制表に則り、各段階で C/P、MPWT 上司と一緒に照査を実施し、修正・変更をしつつ完成版とした（図 8-1）。

その後、全国 24 州の公共事業運輸局(DPWT)に標準図集を送り内容確認・照査依頼を行った。この間、MPWT から要請のあった追加図面（ポステン中空ホロー桁等）の作成作業を並行して実施し完了させた。2012 年 8 月の JCC にて最終的に通達を出すことが決定され、それ以降は本標準図集を用いることになる。

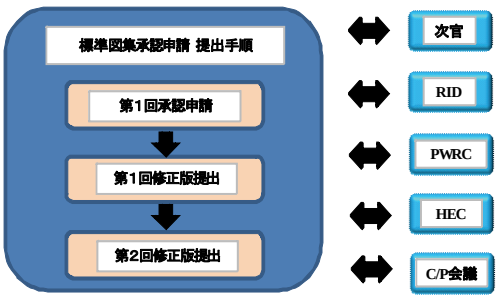


図 8-1　図面提出と修正手順

8.3 標準図集の普及活動

2011 年 12 月 21 日の JCC 会議の後、標準図集の DVD と利用マニュアルが全国 24 州の DPWT に PWRC 局長より送付された。

2012 年 2 月 17 日には、全国 24 州の DPWT からエンジニアの参加を要請し、標準図集に関するセミナーを実施した。講師は、すべてカウンターパートが担当した。

その後、標準図集を正式に引き渡し、MPWT 内のデータベースシステムで標準図集の閲覧が可能となるようにタスク 3 にアップロード作業の依頼を行った。2012 年 6 月末に完成し、標準図集の検索システムも全体データベースに入ることで利便性が向上した。

図 8-2 データベース化された標準図集検索システムの一部

8.4 標準図集の維持管理と更新

今後も新たな竣工図の取りまとめに伴い引き続きデータベースへの入力作業が MPWT 内部で実施されるが、標準図集の維持管理に関しても図 8-3 に示す通り MPWT 内部に新たに標準図集の維持管理グループを設置して主体的に運用することが必要である。現在、カウンターパートが中心になり MPWT 内で具体策を協議中である。

この標準図集維持管理グループにより、今後の竣工図についても収集・保管・活用が実施されるよう提言する。なお、定期的な標準図集の更新（5 年毎目安）も実施されなければならない。

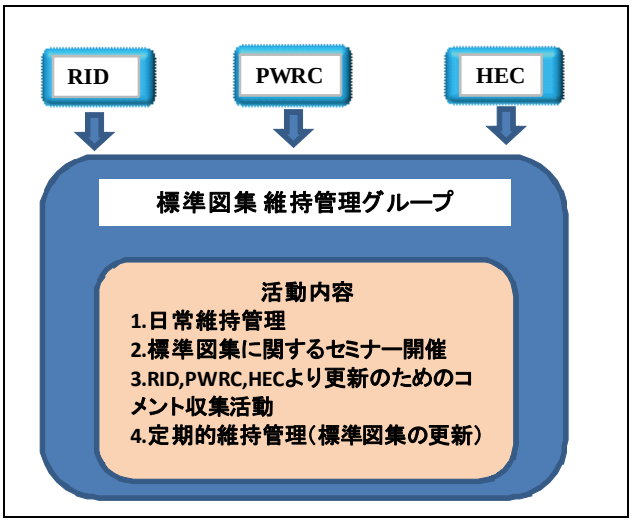


図 8-3 標準図集維持管理体制図

9. 各種会議の開催

9.1 会議記録

本プロジェクトでは、関連部署に業務の節目の適確な時期にプロジェクトの目的から計画の協議及び進捗状況の報告をし、プロジェクト成果の承認のために、各種会議が開催された。主要な会議については、以下の表 9-1 に示す通りであり、本プロジェクトが円滑に運営でき、それぞれのタスクが達成できたのもこれらの会議が機能的であった結果である。

表 9-1 主な会議の概要

委員会		合同調整委員会（Joint Coordinating Committee）	運営委員会（Executive Committee）	マネージメント会議 (Management Meeting)
頻　度		年 1 回	年に必要回数	年の必要時適宜
機　能／承　認		• 年間計画の承認 • 年間計画のレビューと進捗の確認・ｱﾄﾞﾊﾞｲｽ • SG/RG の承認 • 標準図集の編纂の承認 • 研修プログラムの承認 • プロジェクトに関する課題についての協議	• プロジェクト運営 • ４半期計画のレビューと進捗の確認 • タスクフォースのメンバーの任命 • プロジェクトに関する課題についての協議	• プロジェクト進捗の報告 • カウンターパートの配置 • タスクフォースの運営 • パイロットプロジェクトの管理
議　長		MPWT 大臣	MPWT 副大臣	公共事業総局 総局長
メンバー	「カ」国側	MPWT 副大臣 MPWT 次官 公共事業総局総局長・副総局長 公共事業総局内各部 局長 MEF(経済財務省)など関係各省 担当者	MPWT 副大臣 公共事業総局 総局長・副総局長 公共事業総局の各 Department の Director その他関連部署 担当者 MEF	PWRC 局長、副局長 カウンターパート
	日本側	JICA カンボジア事務所 JICA 長期専門家 本プロジェクト JICA 短期専門家（団員）		JICA 長期専門家 本プロジェクト JICA 短期専門家（団員）
回数		3 回	5 回	15 回

上表の他にカウンターパート会議をほぼ毎週実施（全 85 回）し、主に各タスクの進捗の確認と報告を行い、円滑なプロジェクト管理の基礎とした。さらに、タスクごとのアド・ホックな会議を適宜実施した。

尚、各会議におけるプレゼンテーション資料の作成及び発表については、カウンターパートが実行し、JICA 専門家はその支援を行った。

10. JICA 中間評価並びに終了時評価

10.1 中間評価

2011 年 12 月 8 日より 12 月 22 日まで JICA 中間評価が実施された。当初のプロジェクト計画の検証を通じ、実績の確認、実施のプロセス、5 項目（妥当性・有効性・効率性・インパクト・自立発展性）の評価（表 10-1）及び検証を通じての PDM の改訂作業（表 10-2）を実施し、JCC 会議で承認を得た。

表 10-1 5 項目評価

妥当性	プロジェクト目標・上位目標ともに、カ国の上位政策と整合しており、妥当性は高い。
有効性	各アウトプットの実績から判断し、プロジェクト目標は達成される見込みである。基準・取扱要領(SG)と実施規程(RG)を通じて、品質管理活動が標準化されたことで有効性が高い。
効率性	アウトプットは達成見込みであるが、阻害要因も見られた。JICA 短期専門家とカウンターパート(C/P)の配置の遅れでパイロットプロジェクトの実施の遅れにつながり、成果の時期に影響がある。
インパクト	C/P が JICA 専門家から得られた知識や技術の習得により、C/P の能力強化のインパクトは確認できた。尚、負のインパクトは発現していない。
自立発展性	プロジェクトの成果を普及するために既存の研修コースに組み込み、自立発展性はある程度確保されている。

表 10-2 PDM の改訂

	指標	入手手段
プロジェクト目標	１．プロジェクト終了までに SG/RG が改訂され、2013 年からの直営工事の内、2 州以外に 3 州で 3 プロジェクト以上に適用される。	1.1　直営工事実施者に対し、公共事業総局長から適用の指示書を発行する。 1.2　SG/RG 適用対象プロジェクトへのインタービュー。
	２．2012 年実施の研修受講者が品質管理に係るテストで 70 点以上を獲得する。	2.1　マネジメントレベルの講師評価 2.2　受講後のテスト結果
アウトプット 1	プロジェクト終了までに SG/RG の第 2 版が完成する。	1.　SG/RG の第 2 版 2.　MPWT からの省通達

10.2. 終了時評価

2012 年 8 月 20 日より 8 月 30 日まで JICA 終了時評価が実施された。当初のプロジェクト計画の検証を通じ、実績の確認、実施のプロセス、5 項目（妥当性・有効性・効率性・インパクト・自立発展性）の評価（表 10-3）及び検証を通じて本プロジェクト、各アウトプットの達成状況を確認（表 10-4）し、今後の MPWT の品質管理行動について提言を行い、JCC 会議において承認を得た。

表 10-3 5 項目評価

妥当性	プロジェクトの妥当性は高い。 カ国の上位政策のみならず、MPWT のニーズ、日本政府の対カンボジア援助計画、JICA の援助実施方針にも整合している。
有効性	有効性も高い。 SG と RG を通じて品質管理活動が標準化され、標準図集のデータベース化は今後の設計や改修事業に大いに活用できる。
効率性	効率性も確認できた。 パイロットプロジェクトの実施が遅れなければ、さらに良い成果が得られたのではないか。今後プロジェクト終了までの作業の集中化で補う必要がある。
インパクト	インパクトは、相対的に高い。 C/P が JICA 専門家から得られた知識や技術の習得により、C/P の能力強化のインパクトが確認できた。さらに MPWT 自身初めての TCP であったが、各部局で協調し、個人を通して組織の強化も計られた。負のインパクトは発現していない。
自立発展性	財政面の課題はあるものの自立発展性も比較的高かった。 組織的にも技術的にも相当数の職員が品質管理に係る研修を受講し、今後も継続されることが確認できた。

表 10-4 アウトプットの達成状況

アウトプット	指標	達成状況
アウトプット１	プロジェクト終了までに SG/RG の第 2 版が完成する。	1. 5 パイロット・プロジェクトを通じ、SG/RG の第 2 版（英語・クメール語）が発行された。 2. MPWT からの省通達が発令される見込み。 3. 試験所に機器が納入され、据付けられた。
アウトプット２	竣工図書に係るデータベースシステムが構築される。	1. 竣工図書に係るデータベースが構築された。 2. 竣工図面の電子化を行った。 3. 標準図集が編纂され、データベースに収納された。 4. ユーザーマニュアルが作成された。
アウトプット３	MPWT で実施されている定期講習会に参加し、品質管理に係る研修プログラムが作成される。	1. MPWT 既存の研修コースのレビューを行った。 2.トレーナー研修(TOT)を 2 回実施した。 3. 2011 年度より定期講習会に参加し、品質管理に係る講義を行っている。 4. 24 州の DPWT にワークショップを開催した。

10.3. 提言

- MPWT 省通達を発令し、品質管理に係る徹底を計り、サポート体制を確立すること。
- データベースシステムの持続的管理を行うこと。
- MPWT/DPWT 職員に対して、品質管理に係る研修を持続的に実施し、個々のレベルを強化すること。
- 品質管理の重要性について MPWT で共通認識を持ち、自国予算の整備事業で活用すること。
- 予算を確保し、財政面で品質管理行動を阻害することがないようにすること。

11. 今後の品質管理に対する提言

本プロジェクトは表 11-1 に示すように、5 つのタスクと 2 つの追加タスクからなっている。

表 11-1 プロジェクトタスク一覧表

タスク番号 / 内容		章番号
タスク 1-1	基準・取扱要領(SG)と実施規程(RG)の策定	2 章
タスク 1-2	分散性土の道路工事への適用検討	3 章
タスク 1-3	道路台帳の予備的検討	4 章
タスク 2	MPWT 試験所の機材の改良	5 章
タスク 3	竣工図書の集中管理のためのシステム構築	6 章
タスク 4	研修プログラム	7 章
タスク 5	道路及び構造物標準図集の編纂	8 章

各タスクの提言は章ごとに記載されているので、ここでは本プロジェクト全体に関わる提言を列挙する。

(a) **品質管理に係る人的ネットワークの構築：**本プロジェクトが始まってからの 3 年間、多くのカウンターパート(本文の表 1.2-4 参照)が JICA 専門家と業務を共にしてきた。また、パイロットプロジェクトを通じて Party B / C とも工事管理に係る品質管理の面で共同作業を実施した。本プロジェクトが終わった後も、建設の品質管理という共通項を持った人的ネットワークを保持しておくことを推奨する。ネットワークのコアであるカウンターパートや Party B / C が品質管理に係る研修やワークショップの講師を行うことによって、このネットワークを広げていくことが期待できる。建設の品質管理の知識を持った人材が増えることは、MPWT 内の品質管理強化につながっていくはずである。

(b) **サポート体制の確立：** 直営工事において品質管理に係る課題に対応するため、MPWT 内にサポート体制を立ち上げることを提言する。中心になるのは(a)の人的ネットワークのコアメンバーとすることを推奨する。これにより、直営工事の調査、設計、施工段階で発生する各種問題に全省的に取り組むことが可能となる。

(c) **竣工図書の収集：**データベースシステムを実のあるものにするには、多くのデータが格納されていることが必要条件であり、このためには建設プロジェクトの竣工図書の収集が不可欠である。直営工事については実施規程のなかで竣工図書の提出について明記されており、今後はこの規定に従って厳正に対処していくことで目標を達成できる。一方、援助や借款で建設される道路・橋梁については、これまで各援助機関の契約図書により異なった対応がなさ

れてきた。これに対し、直営工事の実施規程を参考にして、全ての援助案件に対し統一的な文言を契約書に入れ竣工図書の収集を図ることを提言する。

(d) **基準・取扱要領、実施規程、データベース、標準図集、研修コースの更新：**すべからく規則・基準・マニュアル類は定期的に更新していかなければならない、といわれる。更新とは、策定されて以後に見出された新しい発見や進歩、その時期の社会現象などを取り入れることであり、定期的に更新をしていかないと、規則・基準・マニュアル類が陳腐化することは避けられない。公共事業研究センター(PWRC)が中心となって、基準・取扱要領、実施規程、データベース、標準図集、研修コースなどの内容を見直すアド・ホックな委員会様の組織を立ち上げて、これらを更新していくことを提言する。

KINGDOM OF CAMBODIA
MINISTRY OF PUBLIC WORKS AND TRANSPORT

KINGDOM OF CAMBODIA

THE PROJECT FOR STRENGTHENING OF CONSTRUCTION QUALITY CONTROL

FINAL REPORT

OCTOBER 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

KATAHIRA & ENGINEERS INTERNATIONAL

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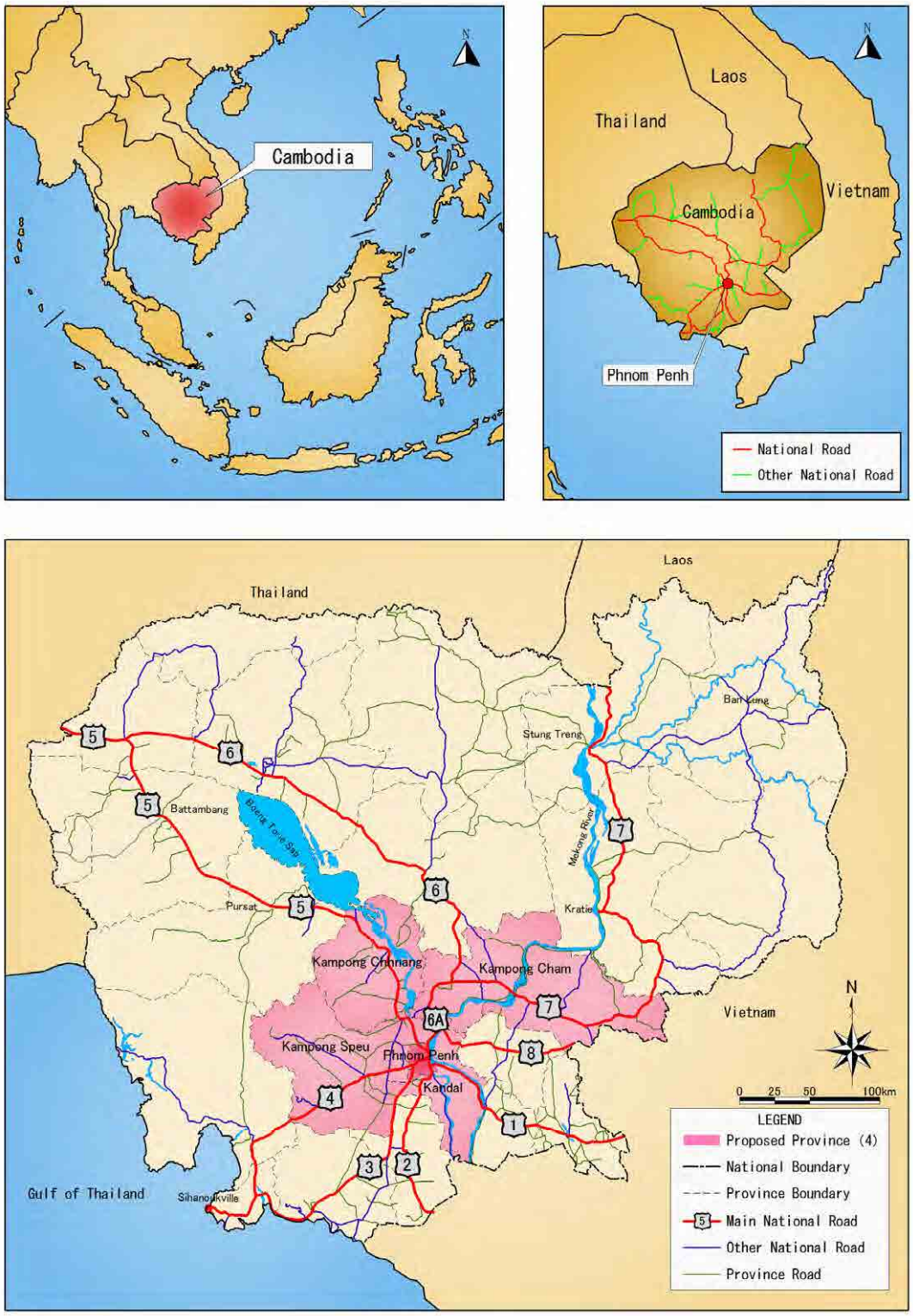

LOCATION MAP

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ABBREVIATIONS

ACD	:	Airport Construction Department
ADB	:	Asian Development Bank
AASHTO	:	American Association of State Highway and Transportation Officials
ASTM	:	American Society of Testing and Materials
C/P	:	Counterpart
DIA	:	Department of Internal Audit
DPWT	:	Department of Public Works and Transport
EC	:	Executive Committee
GDI	:	General Department of Inspection
GIS	:	Geographic Information System
HDM-4	:	Highway Development Management 4
HEC	:	Heavy Equipment Center
HIMS	:	HDM Information Management System
HRD	:	Department of Human Resources
IRI	:	International Roughness Index
JCC	:	Joint Coordinating Committee
JICA	:	Japan International Cooperation Agency
LRCS	:	Location Referencing and Condition Survey
MEF	:	Ministry of Economy and Finance
MM	:	Management Meeting
MPWT	:	Ministry of Public Works and Transport
NSDP	:	National Strategic Development Plan
OFFJT	:	Off-the Job Training
OJT	:	On-the-Job Training
OVI	:	Objectively Verifiable Indicators
PDM	:	Project Design Matrix
PEAC	:	Procurement Evaluation Award Committee
PMU	:	Project Management Unit
PO	:	Plan of Operation

PWL	:	Public Works Laboratory
PWRC	:	Public Works Research Center
QC / QA	:	Quality Control and Quality Assurance
RAMP	:	Road Assets Management Project
RCAF	:	Royal Cambodian Armed Force
RG	:	Regulation
RGC	:	Royal Government of Cambodia
RID	:	Road and Infrastructure Department
RMDS	:	Road Management and Decision Support System
ROMDAS	:	Road Management Data Acquisition System
RSII	:	Rectangular Strategy for Growth, Employment and Efficiency Phase II
SATCC	:	Southern Africa Transport and Communication Committee
SCQC	:	Strengthening of Construction Quality Control
SG	:	Standard Guideline
SII	:	Surface Integrity Index
TCP	:	Technical Cooperation Project
TOT	:	Training of Trainers
TRL	:	Transport Research Laboratory
WB	:	World Bank

CHAPTER 1 INTRODUCTION

1.1 Background of Project

The sustainable rehabilitation and construction of infrastructure is the one of four slogans declared in the Rectangular Strategy of the Royal Government of Cambodia (RGC). In addition, in the National Strategic Development Plan (NSDP) 2006-2010 as a five year action plan of the RGC, 4,100 km out of 11,310 km that is total of one (1) digit and two (2) digits national roads should be paved by 2010. It is also mentioned that the adequate and prioritized road maintenance is a vital action for its achievement.

In order to ensure the efficiency and sustainability of social and economic development and poverty reduction, the Ministry of Public Works and Transport (MPWT) has worked intensively on the rehabilitation and reconstruction of infrastructures such as roads and bridges with financial and technical support from development partners. Regarding the construction projects with financial and technical support from development partners, international consultants have assured quality control by accommodating to the international standard. On the other hand, the national budget construction projects that are implemented by the governmental organizations under MPWT such as the Road Infrastructure Department (RID), Heavy Equipment Center (HEC), and each provincial Department of Public Works and Transport (DPWT) have been inadequate and less effective in terms of quality control of construction so that newly constructed roads and bridges have been easily damaged in a short period of time especially after rainy season. In those situations, several background factors for the weakness in quality control of construction were pointed out by MPWT as follows;-

(1) In some cases, Implementation Bodies (IB) such as RID, HEC and DPWT could not properly implement material testing due to the lack of instruction and the insufficient allocation of budget.

(2) There is few experienced staff with knowledge on quality control of construction in the relevant departments in MPWT.

(3) Laboratory equipment is not good enough to meet the needs of material testing in kind and quantity.

(4) The duty and authority of General Inspectorate and Procurement Evaluation Award Committee (PEAC) are not clearly understood by relevant departments in MPWT related to the function of inspection.

(5) Reports and drawings of past projects which can be reference for designing and planning of new construction are scattered, and no one accesses except their holders.

(6) Current training programs that were implemented by the Department of Human Resources (HRD) tend to mainly focus on administrative matters such as governmental policies and plan etc. due to insufficient number of lecturer resources related to technical matters.

Based on the above-mentioned backgrounds, the RGC requested the implementation of the Technical Cooperation Project (TCP) to the Government of Japan in order to establish an adequate Quality Control and Quality Assurance (QC/QA) system for road and bridge construction. In response to the request from the RGC, the Government of Japan dispatched the experts organized by Japan International Cooperation Agency (JICA).

The TCP policy is to make implementation agency strengthen the ability with their initiative behavior for future activities so that the Strengthening of Construction Quality Control (SCQC) project team (the project team) which composes of MPWT counterparts and JICA experts shall achieve an adequate QC/QA system jointly.

1.2 Project Brief

1.2.1 Project Information

Project Name : The Strengthening of Construction Quality Control Project in Cambodia
Duration of Project : November 27, 2009 to October 31, 2012
Implementation Agency : Public Works Research Center (PWRC), MPWT
Pilot Project Site : Kandal & Kampong Cham (year in 2011)
Kampong Chhnang, Kampong Speu & Bridge Unit (year in 2012)

Working Flow Chart show below;-

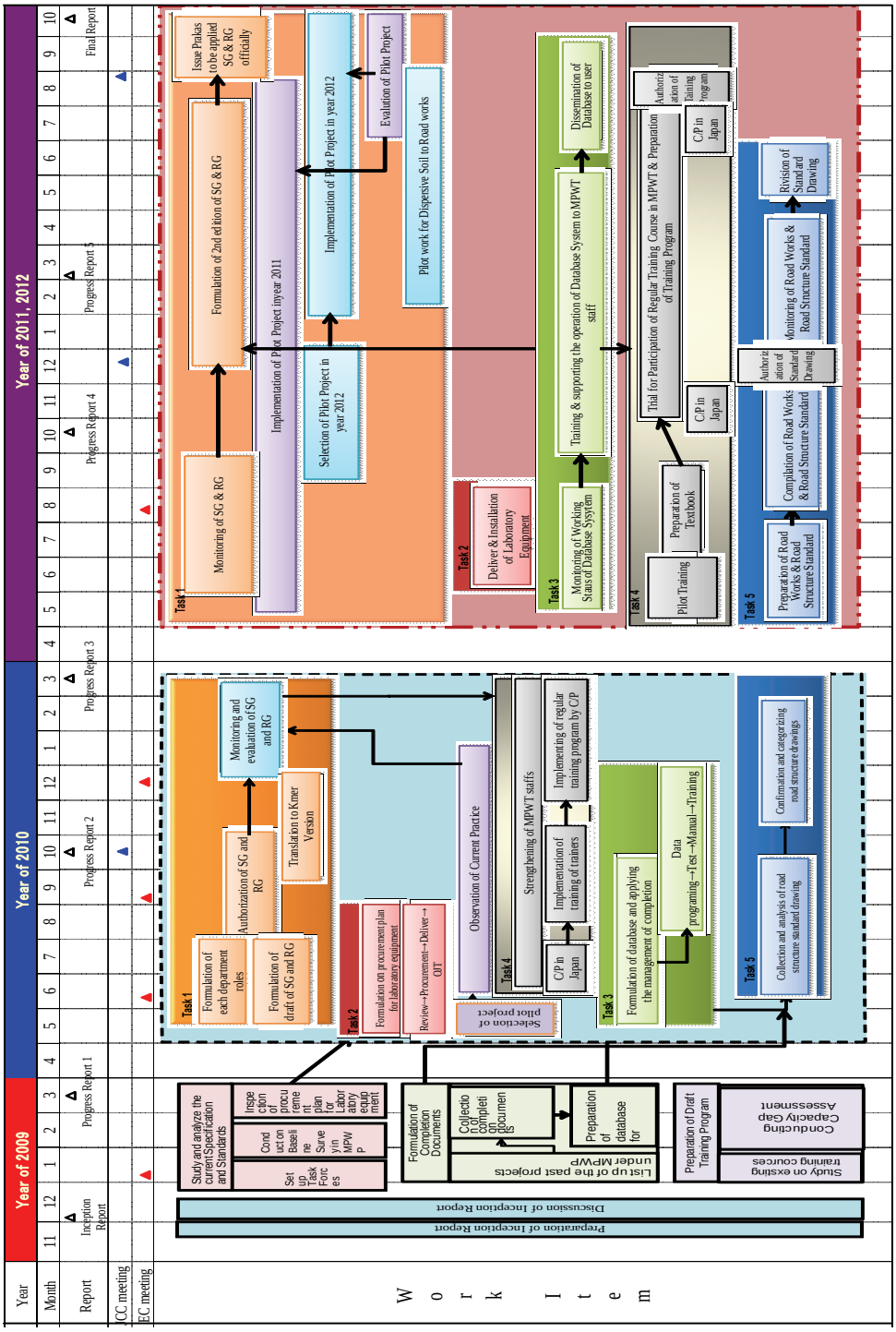


Figure 1.2-1 Project Work Flow

1.2.2 Summary of Project

<Overall Goal>

Quality and cycle of road and bridge construction and maintenance are improved.

<Project Purpose>

Capacity of MPWT engineers in the quality control for road and bridge construction and maintenance undertaken by force account is improved through application of the QC/QA system (Standard Guideline (SG), Regulation (RG), Training and Standard Drawings).

<Outputs>

[Task1] (Output 1-1) :
Establishment and application of Standard guideline (SG) and Regulation (RG) in the quality control for road and bridge construction
[Task 2] (Output 1-2) :
Improvement of laboratory equipment and staffs
[Task 3] (Output 2) :
Establishment of centralized management system for completion documents
[Task 4] (Output 3-1) :
Implementing the technical training for QC/QA by lecturer from MPWT
[Task 5] (Output 3-2) :
Compilation of road and road structure standard drawings

<Activities>

Activities for Output 1

1-1 To conduct the baseline survey on the current duties and capacity of each Department in MPWT relating quality control of construction.
1-2 To set up Task Force for the formulating draft SG and RG.
1-3 To study and analyze the currently applied specifications and standards.
1-4 To formulate the draft RG determining each Department duties for assuring construction quality.
1-5 To formulate SG for actual application of standards.
1-6 To authorize SG and RG by the Joint Coordinating Committee (JCC).
1-7 To formulate procurement plan of laboratory equipment to meet SG.
1-8 To implement pilot projects and to apply SG and RG.
1-9 To officially authorize SG and RG by the Minister of MPWT.
1-9A To be trial construction for dragon hole treatment
1-10 To monitor and evaluate the application of SG and RG.
1-11 To study current practice of road inventory and to propose road data information system

Activities for Output 2

2-1 To list the past implemented construction projects of roads and bridges including development partners funded projects.
2-2 To collect completion documents of construction to MPWT library.
2-3 To categorize all completion documents by road route wise, structure wise and documental type wise.
2-4 To prepare the database with index for reference.
2-4A To formulate the submission procedure of completion document for all of projects including donor funded to connect to road inventory data.
2-5 To formulate database and apply the management to completion document.

Activities for Output 3

3-1 To study and analyze existing training courses.
3-2 To re-design training program with additional technical contents.
3-3 To implement training of trainers (MPWT lecturers).

3-4 To establish Task Force for the "Road and Road Structure Standard Drawings".
3-5 To categorize the road structures and collect ideal road structure drawings from past projects.
3-6 To confirm the worthiness of those road structures in terms of design load, material used, structure, and the actual types of road foundation in Cambodia.
3-7 To compile road and road structure drawings into "Road and Road Structure Standard Drawings" to be authorized by JCC.
3-8 To prepare the curriculum and materials for pilot training.
3-9 To implement pilot training courses for the staff of RID, HEC, DPWT, General Inspectorate and other personnel concerned.
3-10 To authorize the contents of the training program relating quality control by JCC and to officially incorporate into the training course of MPWT
3-11 To implement follow-up survey for participants in order to confirm the degree of understanding and application to actual construction, and to improve the contents of training if necessary.

1.2.3 Revision of Project Design Matrix (PDM)

PDM was prepared and monitored the project outcome in order to manage each activity stated in the Section 1.2.2 during whole period.

After Mid-term Review Team (Review team), organized by JICA, conducted a series of evaluation, the following modifications of PDM were made to clarify the meaning of the narrative summary and the indicators to be measurable.

The original and revised PDM are attached below in Table 1.2-1 and 1.2-2.

Table 1.2-1 Project Design Matrix (Original)

Project name; the Project for Strengthening of Construction Quality Control
Duration; November 2009 --- September 2012
Project implementation Agency; Public Works Research Center (PWRC), Road Infrastructure Department (RID), Heavy Equipment Center (HEC)
Target Group; PWRC, RID, HEC, DPWT (Kandal, Siem Reap, Kampong Cham), Laboratory.

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
(OVERALL GOAL) Quality and Cycle of road and bridge construction and maintenance are improved. 4,100km out of 11,310 km that is total length of 1 digit and 2 digits national roads should be paved by 2010. The adequate and prioritized road maintenance is a vital action for its achievement.	· Increasing Paving (●%, ●m) · Increasing Yearly Maintenance Section (●%, ●m) · Long Paving Life (●Year)	· Annual Report in MPWT · Road Inventory Book	Road Policy in Cambodia will be uncharged.
(PROJECT PURPOSE) Capacity of MPWT engineers in the quality control for road and bridge construction and maintenance undertaken by force account is improved through application of the Quality Control and Quality Assurance (QC/QA) system (standards, regulations, guidelines, trainings).	Full implementation of QC/QA system for 50% of projects of road and bridge construction/maintenance by force account which will be implemented from the beginnings of the 4th year.	· Construction management record, supervising record, inspection record · Progress of 50%, stage of completion and defect period by PEAC	Force account system will remain at least by the end of terms of cooperation. Budget for pilot projects is allocated without any delay.
(OUTPUTS) (Output 1) Standards, regulations, guidelines for quality control of road and bridge construction and maintenance are established and applied. (Output 2) Centralized and integrated management system of completion documents such as drawings reports of construction is established. (Output 3) Technical training for QC/QA by PWRC lecturers is consolidated.	(Output 1) 1-1 To share the standards, Regulations and Guidelines by relevant organization 1-2 To develop the Laboratory Equipments for QC/QA 1-3 To apply the standards, Regulations and Guidelines in force account projects 1-4 To develop the cost estimation system for negotiation of budget between MEF &MPWT. 1-5 To standardize the contract document between DG & DPWT. (Output 2) 2-1 To collect the completion document in Library 2-2 To centralize management to keep the completion documents 2-3 To develop the database system 2-4 To update the information by MPWT Staffs (Output 3) 3-1 To allocate the enough trainers in PWRC 3-2 To update the training program related to QC/QA 3-3 To function the training program under part of whole training program in MPWT. (Dept. personnel) 3-4 To update the Road Structure Standard Drawing 3-5 To put to practical use the Road Structure Standard Drawing in training course.	(Output 1) 1-1 Standards, Regulations and Guidelines 1-2 Construction Report Inspection Report 1-3 Estimation Standard 1-4 Contract and contractor (DPWT, HEC, other government organizations) (Output 2) 2-1 List of database contents 2-2 Usage record to database 2-3 Interview survey to MPWT staffs (Output 3) 3-1 Personnel Composite under PWRC 3-2 Record of training 3-3 Road Structure Standard Drawing	(Output 1) Apply the standards, Regulations and Guidelines officially (Output 2) Reports and drawings of past projects are collected before project begins. (Output 3) Trained engineers continue to work. Budget for capacity development training by MPWT is secured.
(ACTIVITIES) <Year 2009> 1-1 To conduct baseline survey on the current duties and capacity of each Dept. related quality control of construction. 1-2 To set up Task Forces (TF-1, 2) for formulating draft standards, regulations and guidelines. 1-3 To study and analyze the currently applied specifications and standards. <Year 2009 & 2010> 1-4 To formulate draft regulations determining each Dept duties for assuring construction quality. 1-5 To formulate guidelines for actual application of standards. <Year 2010> 1-6 To be authorized the draft standards, regulations and guidelines by the JCC. 1-7 To formulate procurement plan of Laboratory equipments to meet the standards. <Year 2010, 2011, 2012> 1-8 To implement pilot projects and to apply the standards, regulations and guidelines. 1-9 To monitor and evaluate the application of the standards, regulations and guidelines. <Year 2009> 2-1 To list the past implemented construction projects of roads and bridges including development partners funded projects. 2-2 To collect completion documents of construction to the MPWT library. 2-3 To categorize all completion documents by road route wise, structure wise and documental type wise. 2-4 To prepare database with index for reference. <Year 2010> 2-5 To formulate database and apply the management to completion documents. <Year 2009> 3-1 To study and analyze existing training courses. 3-2 To re-design training program with additional technical contents. <Year 2010> 3-3 To implement training of trainers (PWRC lecturers). 3-4 To establish Task Force (TF-3) for the “Road Structure Standard Drawings Collections”. 3-5 To categorize the road structures and collect ideal road structure drawings from past projects. 3-6 To confirm the worthiness of those road structures in terms of design load, material used, structure, and the actual types of road foundation in Cambodia. <Year 2011> 3-7 To compile road structure drawings into the “Road and Bridge Structure Standard Drawing Collections” and to be authorized by JCC. 3-8 To prepare curriculum and materials for pilot training. <Year 2011 & 2012> 3-9 To project and implement pilot training courses for the staff of RID, HEC, DPWT, General Inspectorate and other personnel concerned by PWRC trainers. <Year 2012> 3-10 To be authorized the contents of the pilot training courses by JCC and to officially incorporate into the training course of MPWT. 3-11 To implement follow-up survey for participants in order to confirm the degree of understanding and application to actual construction, and to improve the contents of training if necessary.	**Japanese Side Inputs** 1. Dispatching Japanese experts (1) Long-term Experts a. Chief advisor / road construction and maintenance b. Project coordinator (2) Short-term Experts a. Leader/Quality Management b. Training Development c. Pavement Engineering d. Geotechnical Engineering e. Road Structure Engineering f. Construction Management g. Material Testing h. Database Management System i. Construction Contract Management 2. Provision of machinery and equipments (1) Equipments for laboratory (2) Equipments for library 3. Training in Japan for counterparts 4. Budgetary allocation for project activities	**Cambodian Side Inputs** 1. Assignment of Personnel (1) Counterparts a. Project director b. Project manager c. Deputy project manager for Output 1 d. Deputy project manager for Output 2 e. Deputy project manager for Output 3 f. Deputy project manager g. A full-time staff for the Project (2) Administrative personnel a. Assistants b. Secretaries 2. Provision of buildings and facilities 3. Budgetary allocation for pilot construction projects	Project counterparts continue to work in the counterpart agencies. Trained engineers of road and bridge construction / maintenance continue to work in their agencies. In case, where counterparts or trained engineers are promoted or reassigned, proper turn over and replacement shall be done by DPWT and/or MPWT. **(PRE-CONDITIONS)** The RGC allocates budget for the project without any major delay. Project sites for the pilot projects in three (3) provincial departments are secured. The RGC politic economic and security will be stable growing.

Table 1.2-2 Project Design Matrix (Revised)

Project name; the Project for Strengthening of Construction Quality Control
Duration; November 2009 --- October 2012
Project implementation Agency; Public Works Research Center (PWRC), Road Infrastructure Department (RID), Heavy Equipment Center (HEC)
Target Group; PWRC, RID, HEC, DI, DPWT (Kandal, Kampong Cham, Kampong Chhnang, Kampong Speu,), Bridge Unit and Laboratory.

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
(OVERALL GOAL) Quality and Cycle of road and bridge construction and maintenance are improved.	Large scale defects will not be found on the Defect Liability Inspection in the force account construction projects of MPWT.	1. Inspection record of Defect Liability 2. Site Observation	
(PROJECT PURPOSE) Capacity of MPWT engineers in the quality control for road and bridge construction and maintenance undertaken by force account is improved through application of the Quality Control and Quality Assurance (QC/QA) system (Standard Guideline, regulation, training, Standard Drawings).	1. By the end of the project, the revised SG and RG are applied to at least three force account projects of roads and bridges starting from 2013 (new construction or major rehabilitation under periodic maintenance) in three provinces except in the two pilot provinces. 2. Trainers received TOT are assessed and trainees who participate the annual technical training in year 2012 improve the knowledge level of quality level and score 70 at the post test.	1. A copy of instruction letter from DG of Public Works directing the application of the revised SG and RG to executors 2. Interview to the excutors on the preparation of the project 1. Internal assessment of trainers by management levels 2. Result of training report	1. Appropriate budget to ensure the quality control is allocated for force account projects
(OUTPUTS) (Output 1-1) Establishment and application of Standard Guideline (SG), Regulation (RG), in the quality control for road and bridge construction (Output 1-2) Improvement of laboratory equipment and staffs (Output 2) Establishment of centralized management system for completion documents (Output 3-1) Implementing the technical training for QC/QA by lecturers from MPWT (Output 3-2) Compilation of road and road structure standard drawings	By the end of the project, the second edition of SG and RG are produced after incorporation of the lessons learned from the pilot project Database system is completed, and information of database system is utilized by MPWT staffs Technical training to be formulated in the project will be incorporated into the conventional training program by Department of Personal & Human Resources	1. Revised version of SG and RG 2. Prakas of MPWT 1. List of database contents 2. The number of users 3. The number of record of updating 1. Annual training plan of Department of Personal & Human Resources 2. Record of training 3. Training curriculum and textbooks	1. Force account system will remain at least by the end of terms of cooperation. 2. Budget for pilot project is allocated without any delay. 1. Integrated intranet system in MPWT is established. 1. Trained engineers continue to work. 2. Budget for capacity development training by MPWT is secured.
(ACTIVITIES) 1-1 To conduct baseline survey on the current duties and capacity of each Dept. relating quality control of construction. 1-2 To set up Task Forces for formulating the draft SG and RG. 1-3 To study and analyze the currently applied specifications and standards. 1-4 To formulate the draft RG determining each department duties for assuring construction quality. 1-5 To formulate SG for actual application of standards. 1-6 To be authorized SG and RG by the JCC. 1-7 To formulate procurement plan of Laboratory equipment to meet SG. 1-8 To implement pilot projects and to apply SG and RG. 1-9 To be officially authorized SG and RG by the Minister of MPWT. 1-9A To be trial construction for dragon hall treatment. 1-10 To monitor and evaluate the application of SG and RG 1-11 To study of current practice of road inventory and to propose road data information system. 2-1 To list the past implemented construction projects of roads and bridges including development partners funded projects. 2-2 To collect completion documents of construction to MPWT library. 2-3 To categorize all completion documents by road route, structure and documental type. 2-4 To prepare database with index for reference. 2-4A To formulate the submission procedure of completion document for all of projects including donor funded to connect to road inventory data. 2-5 To formulate database and apply the management to completion documents. 3-1 To study and analyze existing training courses. 3-2 To re-design training program with additional technical contents. 3-3 To implement training of trainers (MPWT lecturers). 3-4 To establish Task Force for the “Road Structure Standard Drawings Collections”. 3-5 To categorize the road structures and collect ideal road structure drawings from past projects. 3-6 To confirm the worthiness of those road structures in terms of design load, material used, structure, and the actual types of road foundation in Cambodia. 3-7 To compile road structure drawings into the “Road and Bridge Structure Standard Drawing Collections” and to be authorized by JCC. 3-8 To prepare curriculum and materials for pilot training. 3-9 To project and implement pilot training courses for the staff of RID, HEC, DPWT, General Inspectorate and other personnel concerned. 3-10 To be authorized the contents of the training program relating quality control by JCC and to officially incorporate into the training course of MPWT. 3-11 To implement follow-up survey for participants in order to confirm the degree of understanding and application to actual construction, and to improve the contents of training if necessary.	**Japanese Side Inputs** 1. Dispatching Japanese experts (1) Long-term Experts a. Chief advisor / road construction and maintenance b. Project coordinator/Library management (2) Short-term Experts ✧ Leader/Contract management ✧ Quality management ✧ Training/Human Resources Development ✧ Pavement engineering ✧ Geotechnical engineering ✧ Bridge/Road structure engineering ✧ System management ✧ Material Testing ✧ Construction management 2. Provision of machinery and equipment (1) Laboratory equipment (2) Equipment for library and Database system 3. Counterpart training in Japan ✧ JFY2010: 3 trainees ✧ JFY2011: 3 trainees ✧ JFY2012: 4 trainees 4. Budgetary allocation for project activities ✧ JFY2009: US$ 52,621.08 ✧ JFY2010: US$ 101,940.65 ✧ JFY2011: US$ 29,782.68 (as of September)	**Cambodian Side Inputs** 1. Assignment of Personnel ✧ Project director (Director General of Public Works) ✧ Project manager (Director of PWRC) ✧ Coordinator: 2 persons (Deputy Director of PWRC) ✧ Technical counterparts: 11 persons (PWRC, HEC, RID, AIC, Laboratory) 2. Provision of budgeting and facilities 3. Budget for pilot project	1. Project counterparts continue to work in the counterpart agencies. 2. Trained engineers of road and bridge construction / maintenance continue to work in their agencies. 3. In case, where counterparts or trained engineers are promoted or reassigned, proper turn over and replacement shall be done by DPWT and/or MPWT. **(PRE-CONDITIONS)** 1. The RGC allocates budget for the project without any major delay. 2. Budget for pilot Project is allocated without any delay, and sites for the pilot projects are secured, and implement in cooperation with DPWT. 3. Counterparts are allocated properly and in cooperation with them.

(1) Project Purpose

The original Objectively Verifiable Indicators (OVI) in the PDM for the "Project Purpose" was pointed out ambiguous and difficult to measure quantitatively at the JICA mid-term review. In addition, the level of capacity of target had to be also measured. In this regards, the Review team proposed to change the OVI and means of verifications as follows;

Project Purpose : Capacity of MPWT engineers in the quality control for road and bridge construction and maintenance undertaken by force account is improved through application of the Quality Control and Quality Assurance (QC/QA) system (Standard, Regulations, Guidelines, Trainings)		
	Objectively Verifiable Indicators	**Means of Verification**
Before	Full implementation of QC/QA system for 50% of projects of road and bridge construction/maintenance by force account which will be implemented from the beginnings of the 4th year.	1. Construction management records 2. Supervising Records 3. Inspection Records
After	1. By the end of the Project, the revised SG and RG are applied to at least three force account projects of roads and bridges starting from 2013 (new construction or major rehabilitation under periodic maintenance) in three provinces except in the two pilot provinces (Kampong Cham and Kandal).	1.1 A copy of instruction letter from the Director General of Public Works of MPWT directing the application of the revised SG and RG to executors (DPWT, RID and HEC) and the confirmation from executors 1.2 Interview to the executors on the preparation of the projects
	2. Trainers received TOT is assessed and trainees who participate the annual technical training in year 2012 improve the knowledge level of quality level and score 70 at the post test.	2.1 Internal assessment of trainers by management levels 2.2 Result of training report

(2) Task 1 (Output 1-1)

The alternative indicator of Output 1 had to be more measurable since it was difficult to measure the level of achievement by the indicator set in the original PDM.

Output 1: Standards, Regulations, Guidelines for quality control of road and bridge construction and maintenance are established.		
	Objectively Verifiable Indicators	**Means of Verification**
Before	QC/QA system will be applied to 100% of projects of road and bridge construction/maintenance by force account which will be implemented from the beginning of the 4th year except emergency work.	1. Contract between MPWT and contractor (DPWT, HEC, other government organization)
After	By the end of the Project, the second edition of SG and RG are produced after incorporation of the lessons learned from the pilot projects.	1. Revised version of SG and RG 2. Prakas of MPWT

(3) Important Assumptions

The Review team proposed to add the following important assumptions.

Level	Additional Imp. Assumption	Reasons
Project Purpose → Overall Goal	Appropriate budget to ensure the quality control is allocated for force account projects.	The budget allocation to conduct activities to ensure the quality is essential.
Output → Project Purpose	Integrated intranet system in MPWT is established.	For wider and easy access of the database is depending on the setting up of integrated internal system in MPWT

(4) Other Minor changes

The Review team proposed the following changes of wording in accordance with the actual situation.

Before	After	Reasons
(Output 3) Technical training lectured by **PWRC** lectures is consolidated by "Road Structure Standard Drawing Collections".	Technical training lectured by **MPWT** lectures is consolidated by "Road Structure Standard Drawing Collections".	Technical trainings are not conducted only by PWRC lectures. TOT was also conducted for MPWT officers from different departments including PWRC, RID, HEC, GI and Laboratory.
(Project Purpose) Capacity of MPWT engineers.. **(Standards, Regulations, Guidelines, Training)**	Capacity of MPWT engineers.. **(Standard Guideline, Regulation, Training, Standard Drawings)**	Initially, the Project planned to produce Standards, Regulations , Guidelines separately. Instead, the Project produced the Standard Guideline and Regulation. Standard Drawings was added since it is also important to ensure QC/QA.
Wording of **"standards, regulations, guidelines" in the Activities 1-2, 1-6, 1-8, 1-9, 1-10 under Output 1**	**Standard Guideline and Regulation**	Same as above (Standard Drawing and Training are the production of Under Output 3)

1.2.4 Activity and Output in Each Task

In order to solve issues under force account project in MPWT, especially for management of quality control, the project team was tackling various activities. The project team aimed to get three (3) times of authorization in JCC meeting, such as "Establishment of SG & RG", "Compilation of Road & Road Structure Standard Drawings", and "Formulation of Training Program". The details of each task activity and process are described in Chapter 2 onward so that this section summarizes overall outcomes of project as shown in Table 1.2.-3.

Figure 1.2-2 describes Project Structure to secure the development of activities.

Table 1.2-3 Overall Outcomes of Project

Task	Activity	Main Outcome
[Task 1 (Output 1-1)] Establishment and application of SG & RG in the quality control for road and bridge construction	✧ Formulation of SG & RG to be applied officially ✧ Monitoring of SG & RG through pilot project ✧ Implementation of pilot work for using dispersive soils in road works	➢ Establishment of SG & RG (English & Khmer) ➢ Prakas of MPWT ➢ Evaluation of pilot project ➢ Recommendation of use of dispersive soils in road works
[Task 2 (Output 1-2)] Improvement of laboratory equipment and staffs	✧ Preparation of procurement plan of necessary laboratory equipment ✧ Installation and training to laboratory staffs how to use and manage equipment	➢ Procurement list for provision of equipment ➢ Record book for laboratory equipment
[Task 3 (Output 2)] Establishment of centralized management system for completion documents	✧ Establishment of database system for completion project ✧ Preparation of duty and responsibility for management of database ✧ Dissemination of database management system to users ✧ Set up mechanism and operation of database system	➢ Database system for completion project ➢ Work procedure of the collection rule (after completion of project, including donor projects)
[Task 4 (Output 3-1)] Implementing the technical training for QC/QA by lecturer from MPWT	✧ Review of conventional training course in MPWT ✧ Conduct on Capacity Gap Assessment ✧ Implementing the training of trainers ✧ Conduct on pilot training ✧ Formulation of adequate training program officially ✧ Implementation of workshop at 24 provincial DPWT	➢ Result of capacity gap assessment ➢ Report on training of trainers ➢ Training program ➢ Training report at 24 provincial DPWT
[Task 5 (Output 3-2)] Compilation of road and road structure drawing	✧ Collection of the past projects drawings ✧ Preparation of compilation of road and road structure drawing officially ✧ Applying and dissemination of standard drawing to force account project	➢ Compilation of road and road structure drawing ➢ Prakas of MPWT

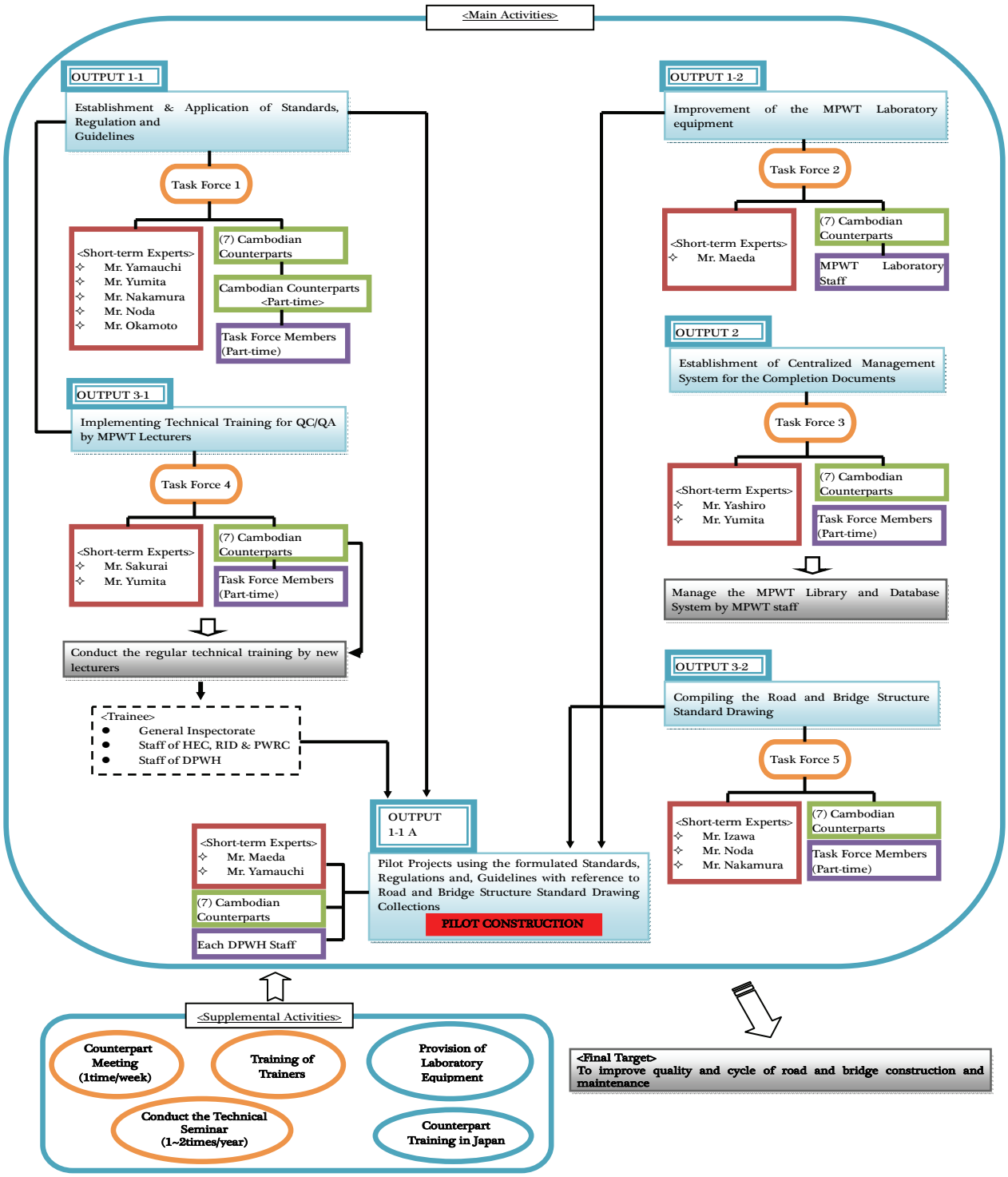


Figure 1.2-2 Project Structure

1.2.5 Assignment of Counterparts and Experts

(1) Counterpart of Cambodian Side

The counterparts of Cambodian side were from RID, PWRC, HEC, Sub-National Public Infrastructure & Engineering, General Department of Inspection (GDI) and Public Works Laboratory in MPWT. The Cambodian side assigned staff for each field are shown in Table 1.2-4.

The JICA experts were planning to build the capacity of C/Ps in charge through the participation in the actual works by on-the-job training. The following points were considered to enhance the capacity for C/Ps.

- To attend all the discussions with stakeholders when experts require.
- To report weekly activities and issues in the C/P Meeting.
- To prepare and translate SG & RG based on the samples prepared by experts and intensive discussions with experts.
- To present project progress to various events such as JCC, Executive Committee (EC) and workshop.

Table 1.2-4 List of Project Member

Task (Output)	Member of Project	
	C/P	JICA Expert
Management of Project	H.E. Kem Borey Mr. Koun Bunthoeun Dr. Khun Sokha Mr. Samrangdy Namo	Mr. Masafumi Yamauchi Mr. Kazuo Yumita
Establishment and Application of Standard Guideline & Regulation	Mr. Chao Sopheak Phibal Mr. Kry Thong Mr. Sok Pounnaraiy Mr. Uy Sophal Mr. Hum Vuthy Mr. Laing Onit Mr. Sang Sinaveth Mr. Phim Phirun	Mr. Masafumi Yamauchi Mr. Yoshihisa Noda Mr. Tomohiko Nakamura Mr. Tatsuro Maeda Mr. Mamoru Izawa Mr. Yoichi Okamoto
Formulation of Procurement Plan of Laboratory Equipment	Mr. Meng Leang	Mr. Tatsuro Maeda
Establishment of Database Management System for Completion Documents	Mr. Ky Soklay Mr. Phy Ratha	Mr. Shuichi Yashiro Mr. Kazuo Yumita
Implementing Technical Training for Quality Control by MPWT Lecturers	Mr. You Dara Mr. Kry Thong Mr. Laing Onit Mr. Nin Menakak Mr. Theng Socheat	Mr. Tatsuyuki Sakurai Mr. Kazuo Yumita
Compilation of Road Works and Road Structure Standard Drawing	Mr. Uy Sophal Mr. Kry Thong Mr. Hum Vuthy Mr. Khun Soth	Mr. Mamoru Izawa Mr. Tomohiko Nakamura
Supervising of Pilot Work (Party C)	Mr. Nou Rethy Mr. Bou Veasna Mr. Pou Manith Mr. Ros Sreng Mr. Leng Song	Mr. Masafumi Yamauchi Mr. Yoshihisa Noda Mr. Tomohiko Nakamura Mr. Tatsuro Maeda Mr. Mamoru Izawa

(2) JICA Expert Team

JICA selected Katahira & Engineers International as a consultant to execute this Project. Katahira & Engineers International dispatched the following experts to carry out this Project.

Table 1.2-5 List of Experts

Name	Specialized Field
Masafumi Yamauchi	Leader/Contract Management
Kazuo Yumita	Deputy Leader/Quality Management
Tatsuyuki Sakurai	Training/Human Resources Development
Yoshihisa Noda	Pavement Engineering
Tomohiko Nakamura	Geotechnical Engineering
Mamoru Izawa	Road Structure Engineering
Tatsuro Maeda	Construction Management/Laboratory
Shuichi Yashiro	System Management
Yoichi Okamoto	Construction for Dispersive Soil

1.2.6 Administration of Project

In order to avoid any conflict and share a similar view between the project team and MPWT during implementing each task, the project team planned the following manner to manage the Project.

Points of Concern
✓ To establish task force in each task to guide the practical outcomes under C/P initiative. ✓ To formulate the contact system in case of difficulties or emergency issues to be resolved during implementation of Project to settle them quickly. ✓ To hold a counterpart meeting every week to grasp each task progress and issues. ✓ To conduct management meeting (MM) regularly to steer each task and evaluate the performance. ✓ To introduce project activities at EC and JCC meeting or other meetings by counterpart (C/P) as presenter. ✓ To publish the newsletter on JICA Home Page to inform the persons related to Project on fundamental knowledge of Project and important outcome.

The JICA experts recognized that C/Ps learned to understand the situations of road management and find solutions by discussion through the above meetings. Furthermore, C/Ps were able to improve their presentation capabilities by reporting the activities performed during EC and JCC meeting.

Thus, the JICA experts observed proof of this improvement not only an individual skill, but also as an organization level in their performance.

1.2.7 Plan of Operation (PO)

The project team has been considering the technology transfer to all of concerned organizations or personnel to improve the quality control system in a sustainable manner after this Project is complete.

PO (refer to Appendix 1) was prepared and has been monitored for the Project in terms of outcome in order to manage the progress of each activity schedule, allocation of staffs and arrangement of necessary equipment during whole period. And PO has been also set up the “monthly activities”, “method of activities” and “evaluation of outcome”. PO management systems are important to renew day by day to input the latest information for the quality control activities.

CHAPTER 2 TASK 1-1 FORMULATION OF STANDARD GUIDELINE (SG) AND REGULATION (RG)

2.1 Necessity of SG / RG

2.1.1 Background

The national budget construction projects that are implemented by the governmental organizations under the MPWT such as the Road Infrastructure Department (RID), Heavy Equipment Center (HEC), and each provincial Department of Public Works and Transport (DPWT) have been inadequate and less effective in terms of quality control of construction. In those national budget projects, material testing and adequate construction procedure seem to be improperly carried out.

With the above observation to the national budget construction projects, baseline survey on practice in the Ministry of Public Works and Transport (MPWT) was planned in order to find out solutions.

2.1.2 Baseline Survey on Practice in MPWT

The baseline survey was conducted by the project team to grasp the situation of activities of construction quality control carried out in MPWT. Main survey items were:

--- What is the role of each department / division in construction quality control,
--- What standards, regulation and guidelines were developed and used in Cambodia, and
--- Which other countries' standards are referred to in Cambodia.

The survey method consisted of hearing survey to officials of concerned departments in MPWT and the officials were answering questionnaires.

The project team carried out the survey from December 8 to 25, 2009. Officers listed below were visited, interviewed and given the questionnaires.

Table 2.1-1 Officers Visited by Expert Team

1. Director General of General Department of Planning and Administration
2. General Department of Inspection (GDI)
3. Director of Department of Internal Audit (DIA)
4. Director of Road and Infrastructure Department (RID)
5. Director of Heavy Equipment Center (HEC)
6. Director of Public Works Research Center (PWRC)
7. Director of Airport Construction Department (ACD)
8. Director of Department of Public Works and Transport (DPWT) in Kandal
9. Director of Public Works Laboratory (PWL)

The results of the questionnaires which officials in MPWT answered are shown in Table 2.1-2 and Table 2.1-3.

Table 2.1-2 Role and Responsibility of Each Department

Roles & responsibilities \ Project		new construction	Re-construction	Periodic maintenance	Routine maintenance	Emergency	Flood
Planning	Survey	HEC	DPWT HEC	DPWT HEC	DPWT	DPWT HEC	DPWT
	Rough design	HEC	DPWT HEC	DPWT HEC	DPWT	DPWT HEC	DPWT
	Estimation	HEC	RID DPWT HEC	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Review of plan	HEC	RID DPWT HEC	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Approval of plan		RID DPWT	RID DPWT	RID DPWT	RID DPWT	RID DPWT
Basic design	Survey	PWRC HEC	PWRC HEC	PWRC HEC		HEC	
	Design	HEC	PWRC HEC	PWRC HEC		HEC	
	Estimation	HEC	RID PWRC HEC	RID PWRC HEC	RID	RID HEC	RID
	Review of design	HEC	PWRC HEC	PWRC HEC		HEC	
	Approval of design	HEC	HEC	HEC		HEC	
Detail design	Survey	PWRC HEC	HEC	HEC		HEC	
	Design	HEC	HEC	HEC		HEC	
	Estimation	HEC	HEC	HEC		HEC	
	Specification	HEC	HEC	HEC		HEC	
	Review of design	HEC	HEC	HEC		HEC	
	Approval of design						
Implementation	Supervision	HEC	RID DPWT HEC	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Quality control	HEC	DPWT HEV	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Schedule	HEC	DPWT HEC	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Site management	HEC	DPWT HEC	RID DPWT HEC	RID DPWT	RID DPWT HEC	RID DPWT
	Test	PWL	PWL DPWT	PWL DPWT	PWL DPWT	PWL DPWT	PWL DPWT
	Inspection		DPWT	DPWT	DPWT	DPWT	DPWT
	Execution	HEC	DPWT HEC	DPWT HEC	DPWT	DPWT HEC	DPWT

Table 2.1-3 Usage of Standards and Guidelines

no	Standards / Guidelines	Frequency of Use in Works	
		Frequently	Sometimes
Standards already identified			
1	Road Law (not approved yet)	DIA	HEC
2	Road Design Standard Part 1,2 & 3	PWRC DPWT	RID HEC
3	Bridge Design Standard	PWRC DIA	RID HEC
4	Standard Traffic Control Devices	PWRC DIA	RID HEC
5	Construction Specification (2003)	PWRC PWL	RID HEC
6	Guideline for Supervision of Routine Maintenance (2008)	DPWT DIA	RID GDI
7	Guideline for Repairing Defects of Roads (2008)	DPWT DIA	RID HEC GDI
8	Guideline for Regular Inspection and Regular Inspection Report (2008)	DPWT DIA	RID HEC GDI
9	Guideline for Supervision or Periodic Maintenance (2008)	DIA	RID HEC
10	IB Performance Evaluation Form (2008)		RID GDI
Other Standards			
11	Compact Construction Material Specification for Maintenance & Construction of Road and Structures	RID	
12	Basic of Technical Standard for Public Works	HEC RID DPWT	
13	AASHTO (American Association of State Highway and Transportation Officials) / ASTM (American Society of Testing and Materials)	PWL DIA	
14	JIS (Japanese Industrial Standards)		PWL
15	AS (Australia Standard)		PWL
16	BS (British Standard)		PWL
17	NZS (New Zealand Standard		PWL
18	NF /EU (France Standard / Europe Standard)		PWL

2.1.3 Necessity of SG / RG

In order to improve the current situation, the project team concluded that technical standard should be prepared for all force account projects and roles and responsibilities of each department be defined specifically by regulation. Hence Standard Guideline (SG) and Regulation (RG) were decided to compile in the Project.

2.2 Process of Formulation of First Edition of SG / RG

2.2.1 Nomination of Counterpart

The first meeting with counterpart (C/P) was held in January 2010. PWRC Director Bunthoeun had briefed the Project and introduced the nine C/Ps appointed in the letter "the Strengthening of Construction Quality Control Project (SCQCP)" from H.E. Tauch Chankosal (Secretary of State) dated December 31, 2009. After the discussion, the following C/Ps were assigned to Task 1 (Output 1-1).

- Chao Phibal (RID)
- Phim Phirun (GDI)
- Sok Pounnaraiy (ACD)
- Uy Sophal (GDI)
- Kong Sophal (PWRC)

The project team was planning to build the capacity of the C/Ps in charge through the participation in the actual works such as identification of the problems, analysis of the problems, or making the measures on the problems. The following points were considered to enhance the capacity of C/Ps.

- To let the C/Ps in charge attend all the discussions with stakeholders.
- To let the C/Ps in charge report the weekly activities in the C/P Meeting.
- To let all the C/Ps discuss and confirm the problems, its analysis and measures in connection with poor quality of the works in the counterpart meeting.
- To let the C/Ps in charge make the new standard guideline and regulation based on the samples prepared by JICA experts and intensive discussions with those experts.

2.2.2 Analysis of Relating Documents

- **Construction Specification (2003)**
  It was compiled under the aid from Australia with MPWT staff as counterparts and is being applied to major construction of roads and bridges in Cambodia.

- **Road Design Standard**
  It was found that:
  This standard was prepared based on the Southern Africa Transport and Communication Commission (SATCC) design guide, which was developed for SATCC for use in Angola, Zambia, Botswana, Zimbabwe etc. For medium to heavy traffic, the design method was based on an AASHTO design equation, whereas previous edition of Road Note 31 was taken into account for light traffic.

  Also, the standard has been very seldom utilized, because the documents are written in English and some important key notes are missing in it.

- **Basic of Technical Standard for Public Works 2005**
  This document was prepared in 2005 to standardize the way of cost estimate. The necessary input items and its quantity for the particular work items are shown in the booklet. All cost estimates done by the department concerned are referred to this document.

- **Compact Construction Materials Specification for Maintenance & Construction of Roads and Structures**
  The document was approved and authorized in January 2010. After being translated, this document was studied and examined. The following points were found.

  - Base is the Construction Specification issued in 2003.
  - Abstract of the clauses concerning the quality control of the materials.

- Introduction of the new pavement material which is not stipulated in the Construction Specification.
- Frequency of the quality control test is omitted from the document, because the warranty clause stipulated in the contract is emphasized instead of the intensity of the quality control.
- It was prepared by RID and it is being utilized for all departments concerned.
- Original document is written in Khmer language

➢ **List of Approved Projects in 2010 under Chapter 21 & 61**

The activity to finalize the budget of chapter 21(New project under the prime minister) and chapter 61(Maintenance project under the minister) respectively was reviewed during the identification of the project flow. Further, the lists of approved projects under chapter 21 & 61 which were the basis of the budget year 2010 were examined. Chapter 21 which budget was 191 billion riels would be implemented by Royal Cambodian Armed Force (RCAF), HEC, RID road unit and DPWT. It was also confirmed that the proposed projects were concentrated in the particular areas. Chapter 61 which budget was 150 billion riels would be implemented by only DPWT except one project by HEC. 150 billion riels were divided into three categories which were 63 billion riels for periodic maintenance, 75 billion riels for routine maintenance and 12 billion riels for emergency purposes

➢ **Regulation of Each Department in MPWT（Sub Decree）**

The sub decrees (Khmer language) stipulating the roles and responsibilities of each department were collected and those related to force account projects, such as MPWT, RID, PWRC, HEC, GDI and DPWT were translated to English language. Translated documents were reviewed and it was confirmed that those departments and organizations would cover wide range of work scope in respect of road and bridge construction and maintenance.

In order to strengthen supervision on the project, RID and PWRC were expected to be the party for supervising force account projects. However the latter (PWRC) was not able to supervise the project at the time of survey in accordance with then sub decree. Consequently the sub decree for PWRC would be revised to allow PWRC to supervise project (later it was found that revising of the sub decree was being processed).

After reviewing sub decrees, the project team concluded at this stage that new regulation would not conflict with the stipulation in the sub decrees.

➢ **Series of Documents concerning Project Implementation**

Following documents in each type of project, such as routine, periodic and new construction were found.

1. Proposal with cost estimate and basic design
2. Approved document for budgeting with cost estimate and design
3. Contract between MPWT and the Department concerned
4. Interim inspection
5. Final inspection
6. Warranty inspection

These documents significantly contributed to indentify and finalize the flow of the implementation of the force account projects.

➢ **Proposed Contract Document Prepared by MPWT**

This document was suggested by the Project Director H. E. Kem Borey (Director General of General Department of Public Works) in the management meeting in February 2010 to study in order to reflect to new regulation.

It was found that this draft of the contract aims to projects for contract out upon referring to World Bank (WB) and Asian Development Bank (ADB) contract forms. The supervision clause in this document may be adopted in part for the formulation of new regulation.

- **Contract Agreements for Force Account Projects**
  Several contract agreements used in the current projects implementation were examined. It was found that there were no much differences between agreements. These may be references for preparing standard form of contract agreement. This is part of systematization and standardization of contract document.

2.2.3 Identification of Flow of Activities of MPWT Force Account Project and Problems / Measures

This Task is to establish standard guideline and regulation for quality control of road and bridge construction and maintenance undertaken by force account. The activities to achieve this Task were as follows;

1) to conduct baseline survey
2) to set up Task force
3) to study and analyze the standards, regulation and guidelines currently adopted
4) to identify the flow of activities to implement the projects
5) to indentify the problems to ensure the quality of the works
6) to formulate the standard guideline and regulation

The activities from 1) to 3) are mentioned in the previous sections. The activities 4) and 5) were being worked on. As part of these activities, Flow of Activities with Problems and Measures on MPWT Force Account Project (ref. Figure 2.2-1) was prepared by Task force upon several discussions with the stake folders listed below.

RID Director	Mr. Nou Vaddhanak
RID Deputy Director	Mr. Nay Chamnang
RID	Mr. You dara
PWRC Director	Mr. Koun Bunthoeun
HEC Director	Mr. Phy Lyda
HEC	Mr. Kri thong
DPWT	Deputy Directors

In the process of the identification of the flow, the two major problems (insufficient budget and improper quality control) were identified.

So far, the cost estimate had been prepared with one typical section of pavement (base course 200mm, sub-base course 200mm) and the guideline issued in 2005. This budget could not be altered with variation of the pavement formation, resulting from unanticipated sub-soil to encounter. The procedure to enable to vary the design of pavement section had to be introduced. Further, 2% of direct cost, which is allowed for fee of study, plan and inspection was considered not enough to conduct the quality control activities mentioned below.

In terms of the quality control, the project team found that supervisory team/staff was not deployed sufficiently and daily quality control was not often conducted. In this regards, the project team recommended the following points.

1. Implementation of the daily quality control and custody of the records

2. New deployment of the supervisory team/staff

This flow with problems and measures on MPWT force account project (Figure 2.2-1) was presented in the management meeting in February 2010 headed by H.E. Kem Borey (Project

Director) and was still being confirmed by the series of discussions in the stakeholder meetings.

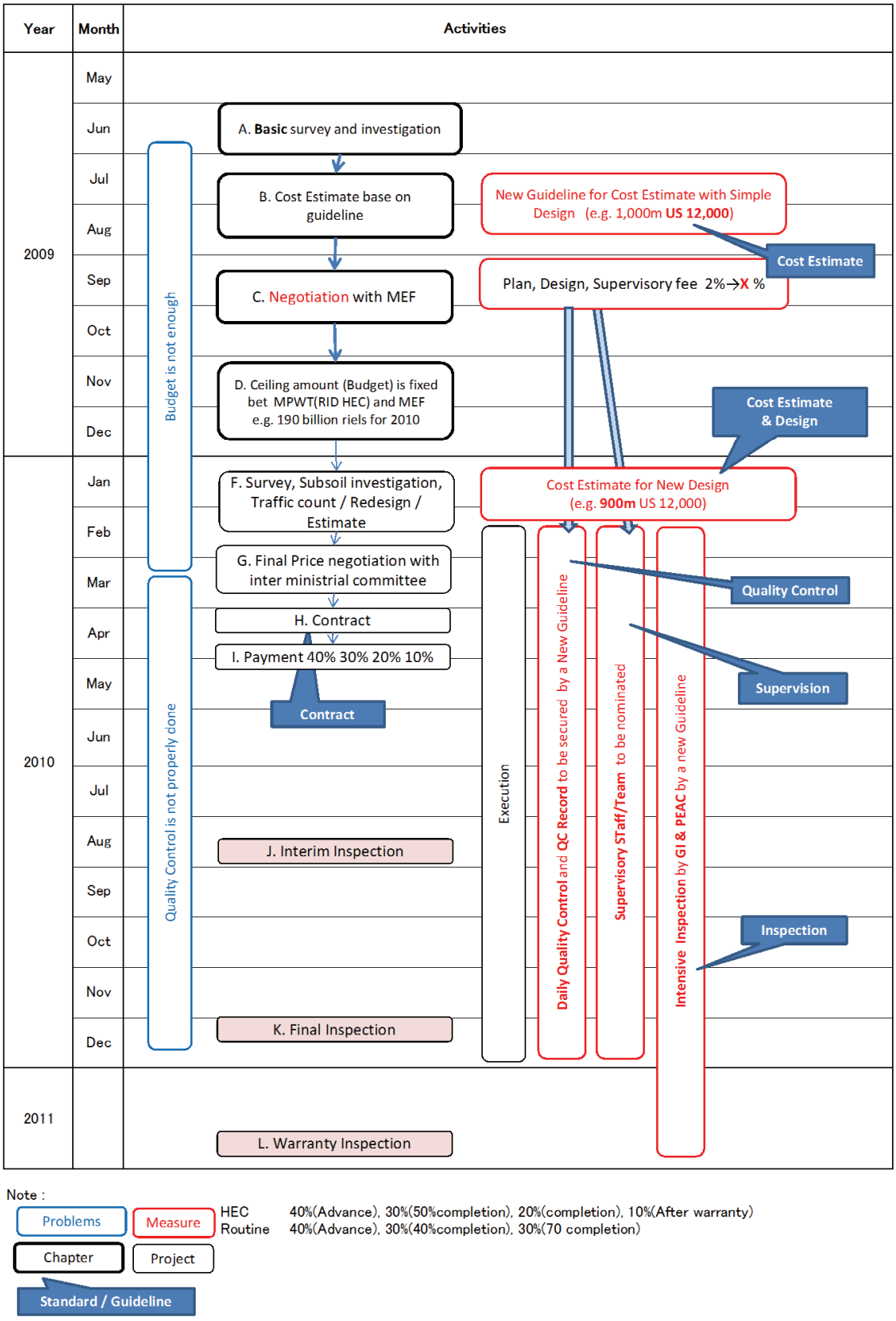


Figure 2.2-1 Flow of Activities with Problems and Measures on MPWT Force Account Project

2.2.4 Proposed Design Concept

As explained in Section 2.2.3, the cost estimate in basic design had been prepared with one typical section of pavement (base course 200mm, sub-base course 200mm) and the guideline issued in 2005.

In the proposed new design, the project team considered that at the basic design stage, the pavement design would be done based on the geographical formation without any geotechnical and traffic survey due to time constraint, and at detailed design stage, the pavement design would be revised based on the CBR value and N_{esa} (cumulative number of equivalent standard axles) which is to be confirmed during this stage. Hereunder, the definition of Traffic Class and Sub-grade Class missing out in the current design standard is specified in the following Table 2.2-1 and the concept of new design standard prepared based on Transport Research Laboratory (TRL) Overseas Road Note 31 is shown in Figure 2.2-2 Concept of New Proposed Design Standard. The concept of current and new proposed design guideline is shown in Figure 2.2-3 Concept of Current and New Proposed Design Guideline.

Table 2.2-1 Key to Design Chart in TRL Overseas Road Note 31

Traffic	10^6 CN_{esa}	Subgrade Class	CBR %
T1	<0.3	S1	2
T2	0.3 – 0.7	S2	3-4
T3	0.7 – 1.5	S3	5 – 7
T4	1.5 – 3.0	S4	8 - 14
T5	3.0 – 6.0	S5	15 – 29
T6	6.0 – 10	S6	>30
T7	10 – 17		
T8	17 - 30		

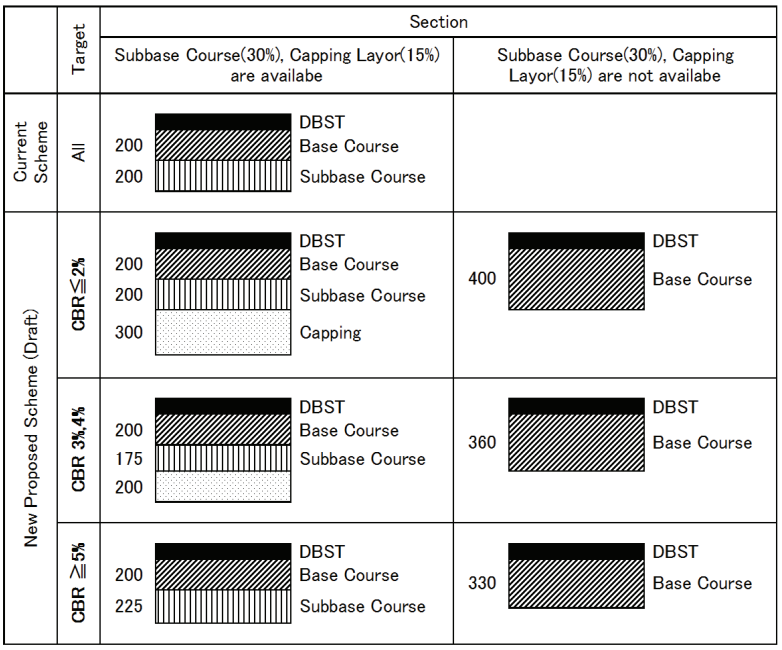


Figure 2.2-2 Concept of New Proposed Design Standard

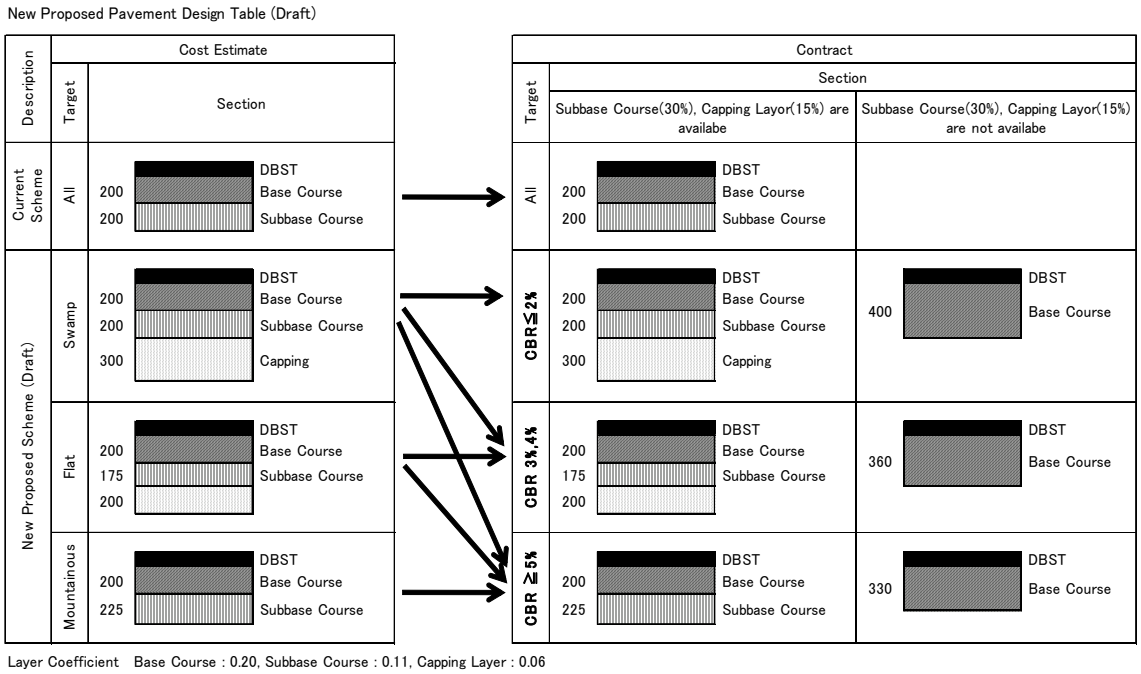


Figure 2.2-3 Concept of Current and New Proposed Design Guideline

2.2.5 Draft of Table of Contents of Standard Guideline

The draft of table of contents of Standard Guideline (SG) was prepared with the counterparts based on the flow of the force account project with the problems and measures. It was presented in the C/Ps meeting in February 2010 and the management meeting in March 2010. The main points focused on are as follows.

1. Strengthening of the supervisory service upon nomination of the supervisory team / staff
2. Introduction of the new design standard.
3. Strengthening of the Quality Control / Quality Control Chart (summary and quality control standard) to compile
4. Strengthening of the As-built Control / As-built Control Chart (summary and as-built control standard) to compile
5. Evaluation of the performance of the implementing body (Guideline had been prepared already)

The draft of table of contents was confirmed by the C/Ps meeting in February 2010. And the SG writing was assigned and shared among C/Ps in charge in the Task 1 meeting in March 2010.

2.2.6 Draft of Table of Contents of Regulation

Following the activity flow of force account project in Section 2.2.3, table for roles and responsibilities of concerned parties in force account project was prepared together with the counterparts in charge of Task 1and explained in the C/P meeting in February 2010.

Taking the roles of concerned parties into consideration, draft version of table of contents of regulation and formation of concerned parties during construction (see Figure 2.2-4) were produced. Both were presented in the management meeting and the C/P meeting in March 2010.

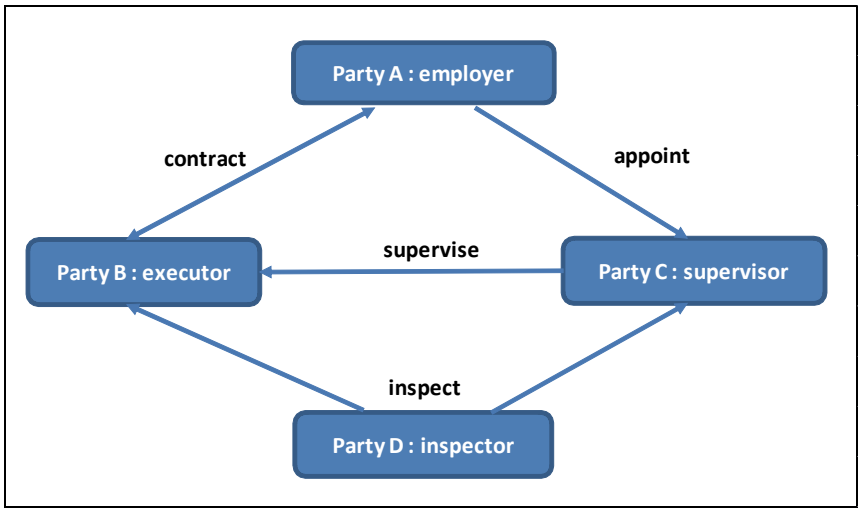


Figure 2.2-4 Formation of Concerned Parties during Construction

After discussing with the C/Ps in charge for Task 1, table of contents of regulation was confirmed as draft and it was agreed in the meeting held in March 2010 that each C/P would write up certain sections of the regulation.

2.2.7 Preparation of Form of Contract

Based on the review to current contract agreement and referred to the newly proposed contract document for contract out (both explained in Section 2.2.2), form of contract was being prepared for total systematization and standardization.

2.2.8 Issues to be Addressed and Resolved

The followings are the issues for Task 1 and to be resolved in order to strengthen and improve quality of force account projects.

- The C/Ps in charge of Task 1 shall have enough time to write up new standard guideline and regulation, since they are so capable to do so.
- New supervisory team / staff shall be appointed for force account project.
- The additional supervisory fee is needed to enable to comply with new standard guideline and regulation and shall be paid directly to supervisory team.
- Design change shall be made during construction to accommodate different conditions in the design stage, when unforeseen conditions are encountered.
- The new standard guideline and regulation in terms of the new design, additional supervisory fee and design change shall be explained to MEF for their consents.
- The instruments required for the daily quality control such as field density test or sieves shall be deployed for each implementing body such as DPWT, HEC and RID etc.

2.2.9 Draft of SG / RG and Briefing to Stakeholders

- Progress of writing up SG and RG assigned to each counterpart was checked.
- Among the C/Ps, meetings for discussion were arranged and there became more common knowledge in this regard.
- Documents for explaining concept of SG and RG were being prepared for second EC meeting scheduled in June 2010.

- Presentation materials for SG and RG were prepared and presented by C/Ps in the second EC meeting as well.
- First draft of SG and RG was compiled after collecting papers written by each C/P and disseminated to all C/Ps in the regular C/P meeting in June 2010. Briefing materials prepared with power point were also presented in the same meeting.
- Briefing materials on the SG and RG were translated into Khmer language. The project team visited the DPWT to explain the draft of SG and RG in June to August 2010.
- Final draft of SG and RG was compiled and sent to relevant 24 provincial DPWTs and MPWT by the end of July 2010.
- The project team also visited and explained the draft of SG and RG to the main players in MPWT and important DPWT for further understanding as shown in Table 2.2-2.

Table 2.2-2 Briefing on SG / RG to Stakeholders in June to August 2010

No.	Date	MPWT / DPWT	C/P
1	June 29, 2010	Phnom Penh	Mr. Phibal
2	June 30, 2010	Pursat	Mr. Namo
3	July 01, 2010	Kandal	Mr. Kry Thong
4	July 02, 2010	HEC	Mr. Kry Thong
5	July 05, 2010	Kampong Cham	Mr. Kry Thong
6	July 05, 2010	Kratie	Mr. Kry Thong
7	July 08, 2010	Battambang	Mr. Kry Thong
8	July 09, 2010	Pailin	Mr. Kry Thong
9	July 23,2 010	Oddarmeanchey	Mr. Namo
10	August 04, 2010	Oddarmeanchey	Mr. Namo
11	August 04, 2010	RID	Mr. Phibal

2.2.10 Discussion and Incorporation of Comments from Stakeholders

- The 37 comments or advices were received as shown in the Table 2.2-3 below. The project team discussed with relevant parties and prepared the actions on comments or advices.
- The actions on comments or advices were approved by PWRC Director Bunthoeun in the C/P meeting on August 6, 2010 with minor revisions.
- The approved actions on comments or advices were finally approved by H.E. Kem Borey in the management meeting on August 9, 2010.
- The English and Khmer version of the first edition of SG and RG (after revision on the final draft) were prepared based on the further discussion in the C/P meeting on August 20, 2010. The briefing materials on the SG and RG were also prepared.

Table 2.2-3 Comments on SG and RG after Discussion in C/Ps Meeting in August 2010

No.	SG/RG	Comments or Advices	From	Actions
1	SG	Not only DBST but also AC should be included in design concept.	C/P	AC to be added
2	SG	"Sub course" must be corrected to "Base course" in As built Measurement Record Form.	C/P	Corrected
3	SG	The frequency of proof rolling should be discussed.	C/P	After discussed, the frequency to remain no change
4	SG	"G: Good" should be corrected to "P: Passed" in Check Sheet for Proof Rolling.	C/P	Corrected
5	RG	Not only Party C but Party C and Party D shall be a evaluator in Clause 10 Appraisal of Project in Section 2	C/P	Corrected
6	RG	When Appraisal of Project to be conducted should be discussed.	C/P	After discussed, appraisal in RG to remain no change
7	SG	Standard forms for Quality Control should be prepared.	Expert	Standard forms shall be prepared at later stage, when necessity arises
8	SG	P5 "the detailed design shall follow the basic design / soil investigation can be omitted" should be changed to "at least one location of the sampling shall be selected" because engineering judgment is necessary even if the section length is shorter than 200m.	Expert	To be corrected
9	SG	P8 "However, if the length of the one section of the proposed project is shorter than 200m, the basic design shall prevail." should be deleted because engineering judgment is necessary even if the section length is shorter than 200m.	Expert	To be corrected
10	SG	Detailed inspection form is necessary.	C/P	Form of "Request for Inspection" is included in Appendix F. Forms for quality control are stated in item 7.
11	SG	Supervision guideline is necessary.	C/P	After discussed, no additional documents to prepare
12	SG	In detailed design can not propose cumulative traffic count but daily traffic count be used?	Expert	To be incorporated
13	RG	Can SG/RG apply to works implemented by Army Force and Police Office whose contract is made by MPWT?	C/P	Statement of 1. Scope in I General Provision shall be revised in order to apply SG_RG to the works by army force and police office

No.	SG/RG	Comments or Advices	From	Actions
14	RG	RID performs as Party B and Party C in one project. It is doubt that supervision could be implemented well with such formation.	Stake-holder	After discussed, RG in this respect to remain no change
15	RG	Approval of budget increase & party C expense separated from Party B is key and difficult task.	Stake-holder	To explain and convince MEF for these points
16	RG	If Party D rejects the works at inspection, what are going to happen?	Stake-holder	If following SG_RG, no rejection would occur.
17	RG	If event classified in force majeure occurs, what would be the outcome?	Stake-holder	Additional clause shall be added by reference to appropriate clause in FIDIC
18	SG/RG	How would SG/RG be made popular to all stakeholders?	Stake-holder	Training course to all stakeholders will be commenced in October this year under SCQC project.
19	SG/GS	It is concerned that response to documents submission for approval is late and site inspection for daily QC is delayed.	Stake-holder	In general, response from Party C to Party B is stipulated to be within limited time. Full time inspector from Party C shall be assigned.
20	RG	If stop order is issued, what is going to happen?	Stake-holder	Stop order is limited to the works improperly implemented and the order shall be lifted up, when the works become in order.
21	RG	Cumulative payment at completion is 90 % only and 10 % is released at expiry of warranty period. Party B could not cover the cost till this 10 %.	Stake-holder	This is problem in method of cost calculation. To be discussed at later stage.
22	RG	Party C shall calculate expense for supervision, meeting the requirements in SG/RG.	Expert	Party C (PWRC/RID) shall make plan for supervision and calculate expense for it.
23	RG	Contract between Party A and Party C shall be prepared and signed, like the contract between Party A and Party B.	Stake-holder	Annex B for form of contract agreement between Party A and Party C shall be added.
24	SG	Work code and unit price for routine road maintenance in Table 3-1 & 5-1 shall be updated.	C/Ps	Table 3-1 & 5-1 to be replaced with full work code list without unit price
25	SG	DPWT shall be included as the executor in Chapter 21 in Table 2-1 and 7-1.	Stake-holder	To be corrected
26	SG	The provision for traffic safety and removal / relocation / shifting of utilities (cable, telephone, water etc.) shall be included in the cost estimation.	Stake-holder	Statement of the left to be added in 5.1 and 10.1.

No.	SG/RG	Comments or Advices	From	Actions
27	SG	Price adjustment in each year shall be needed for routine maintenance.	Stake-holder	Current price to be used in every year and see item 24.
28	RG	Flood like the flood from Prek Thnot river in Phnom Penh shall be included as unforeseen physical conditions.	Stake-holder	To be corrected in 9.5, however flood to be substantiated to be unforeseeable.
29	RG	Who shall prepare monthly report and inspection report?	Stake-holder	Monthly report to be prepared by Party B. Inspection report to be prepared by Party B and certified by Party C. original of inspection report to be kept by Party B for payment purpose.
30	SG	Equipment for daily quality test like field density test shall be kept on site for carrying out tests at proper timing.	Stake-holder	Certain equipment to be provided through SCQC project by JICA.
31	SG	Wastage factor for material shall be calculated in estimation, such as compaction, transportation and storage etc.	Stake-holder	Take note
32	RG	Would defect liability period be set more flexible as laterite road is very vulnerable?	Stake-holder	Take note and to be discussed at later stage
33	SG	HEC to be included as executor and PWRC to be as inspector in chapter 61 (periodic) in Table 2-1 and the same to apply in Table 7-1	C/Ps	To be corrected
34	SG	Geodetic survey and hydraulic and hydrological survey to add in 3.1, page 2	C/Ps	To be incorporated
35	RG	Duration to review documents and cost estimation is allowed only one week, which seems too short.	C/Ps	Instead of one week, duration for review and response to revise two weeks
36	SG/RG	In the Request of Inspection, is Party B allowed to proceed to the works with comments, in the case some things need to be corrected before the requested works can be started?	C/Ps	Party B to be allowed in such case.
37	SG	In order to make improvement of quality and management, check lists showing test method, standard and test frequency in each activity shall be prepared with work procedures.	Stake-holder	For documentation for improvement, check lists for earthwork, concrete work and pavement work has been prepared and included in Appendix G.

2.3 Approval of First Edition of SG / RG

On August 27, 2010, the project team explained and discussed with the Department of Investment and Cooperation of Ministry of Economy and Finance (MEF) about the SG and RG. Also on the same day, the project team conducted a seminar on the SG and RG to MPWT and 24 provincial DPWTs for better understanding.

The detailed explanation and discussion on the first edition of SG and RG was done in the third EC meeting on September 1, 2010. The uniformity of the terms in Khmer language was requested by EC members, though the contents were agreed by them. The commencement of the selection of pilot projects and cost estimate for supervision were also agreed by EC members. If the additional cost to comply with the SG and RG is incurred, the cost may be shared.

The SG and RG were eventually approved to introduce by the Joint Coordinating Committee (JCC) meeting on October 13, 2010. In order to apply the SG and RG in MPWT sustainably, the project team was implementing the activities to achieve the tasks such as preparation work for pilot project in year 2011. The followings were the issues to be addressed.

- The daily quality control stipulated in the SG needs to have enough staffs and budget. In case of any constraint arise, SG shall be revised accordingly because key to SG is prepared based on the daily quality control on site.
- Timing of appointment of Party B & C which is responsible to Party A shall be carefully reviewed and specified because the activities in accordance with the SG and RG must start before approval of the projects. Appointment of the parties before approval of the project would be difficult.
- How to apply the SG & RG before approval of each project shall be considered because basic study and design is conducted before contract between Party A and B.
- A model regarding construction plan shall be prepared, reflecting the lessons learnt from the pilot projects in year 2010.
- In case of occurrences of deviations from the assumptions during preparation work such as soil test, the SG & RG shall be specified and revised clearly after discussion with MEF.
- Prioritization of the activities required in the SG & RG shall be specified because all the activities cannot be complied especially for small scale works.
- The record of photographs is one of site management method. Project team needs further discussion whether this photo recording is specified in the SG or not.

2.4 Process of Formulation of Second Edition of SG / RG

2.4.1 Set-up of Task Force

First edition of SG and RG were approved by JCC meeting in 2010 and since then, those were being utilized in the pilot projects of 2011 and the trainings / workshops conducted in 2011. Those and the draft version of SG second edition were referred in the pilot projects of 2012 and the trainings / workshops in 2012.

The mid-term review mission, organized by JICA came to the Project in December 2011 (details of which are stated in Chapter 10) and recommended that second edition of SG and RG had to be compiled within the period of the Project, based on the experiences from the pilot projects. Figure 2.4-1 shows overall schedule for the formulation of SG / RG and force account projects

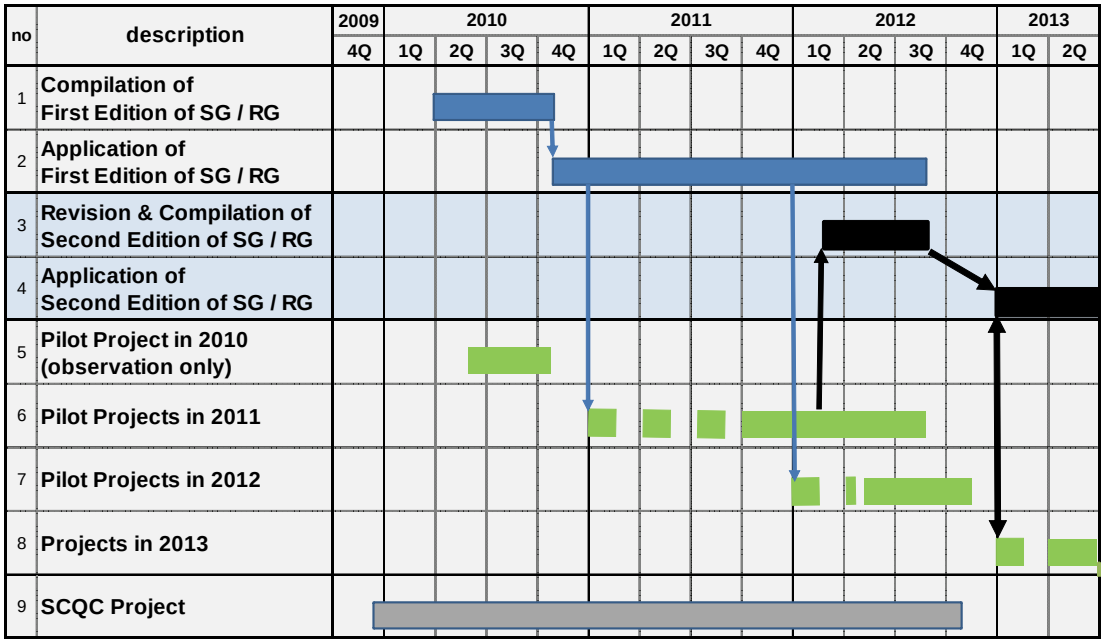


Figure 2.4-1 Schedule of SG / RG and Pilot Projects

Based on the schedule above, Task force 1 was set again at the end of February 2012 for formulation of second edition of SG / RG and the first meeting was called at the end of February 2012.

- Member CP Messieurs Namo, Phibal, Thong, Leang, Vuthy, Onit, Menakak
  Party B* DPWT K. Cham, Kandal, K. Speu, K. Chhnang
  Party C* Messieurs Rethy, Veasna, Sreng, Manith, Piseth, Song
  JICA Experts
  *ad-hoc member
- Major contents of editions
  - To add section for piling works of bridge construction
  - To incorporate comments from the mid-term review mission
  - To add quality record forms like compaction tests etc.
  - To discuss and incorporate inputs from Party B and C
  - To discuss and incorporate ideas on first edition of the SG / RG from CPs and experts

2.4.2 Discussion and Formulation of Second Edition of SG / RG

Task 1 meetings were held in February to April 2012 five times and the draft was drawn at the end of April 2012, main revisions of which are shown in Table 2.4-1 below.

Table 2.4-1 Revision of Second Edition of SG / RG

[SG]

- Clause 4 Basic Design
  (2) Structure Design is added for bridge construction in clause 4.1
- Clause 8 Detailed Investigation and Survey
  Sub-soil investigation is added for piling works in bridge construction in clause 8.1.
- Clause 9 Detailed Design
  (3) Structure design is added for bridge construction in clause 9.1.
- Structure of Clause 11: changed as below

11.1 Earth Works	⇨	11.1 Earth Works
11.2 Concrete Works		11.2 Pavement Works
11.3 Asphalt Works		11.3 Piling Works
-		11.4 Concrete Works

- Clause 11.3 Piling Works
  Whole Clause 11.3 is newly compiled.
- Clause 11.4 Concrete Works
  Box and pipe culvert is added in Table 11-8 As-Built Control Chart for Concrete Works
- Structure of Appendix: changed as below

Appendix A As-Built Measurement Record Form	⇨	Appendix A As-Built Measurement Record Form
Appendix B Sand Cone Test Method and Test Sheet		Appendix B Sand Cone Test Method and Test Sheet
Appendix C Check Sheet for Proof Rolling		Appendix C Check Sheet for Proof Rolling
Appendix D Daily Quality Control Sheet for Concrete Works		Appendix D Check Sheet for Application of Bitumen Material
Appendix E Check Sheet for Application of Bitumen Material		Appendix E Quality Control Sheet for Piling Works
Appendix F Request for Inspection		Appendix F Quality Control Sheet for Concrete Works
Appendix G Documentation for Improvement		Appendix G Documentation for Improvement
-		Appendix H Request for Inspection

- Appendix A As-Built Measurement Record Form
  Items for box and pipe culvert are added.
- Appendix E Quality Control Sheet for Piling Works
  Three sheets are newly compiled.
- Appendix G Documentation for Improvement
  Check List for Piling Works is newly compiled.

[RG]

- Clause 9.4 Contract Documents and As-Build Documents
  3) "Project information" is to provide as part of as-build contract document, format of which is enclosed as annex to RG.
- Clause 9.6 Programme, Progress and Meetings / Reports
  3) "Party C monthly report" is added on top of Party B monthly report.
- Clause 9.11 Variations
  2) Sentence "Party B shall submit monetary proposal" is added
- "Form of Contract (Party A and B) in Annex A
  Form is to revise as per the agreement currently used.
- "Form of Contract (Party A and C) in Annex B
  Form is to be deleted.

After one month period for reading the draft of second edition of SG / RG and comments on the draft, the Task 1 meetings were resumed in June 2012 and continued in four times till July 2012 for finalization and preparation of Khmer version of the second edition. During this period, there were comments provided and actions taken, which are shown in Table 2.4-2.

Table 2.4-2 Comments and Actions to Second Edition of SG / RG

no	Comments	SG/RG	clause	Comments & Resolution	Action
1	Party C	RG	Annex B	Item 3-3: "Completion Date" to "Completion Date certified by Party D	No change, as completion date is obviously certified by Party D
2	CP	SG	Clause 9	Traffic survey to be stated in more detail and application of traffic survey result to design to be explained	To review and add something
3	Party C	SG	Appendix A	Figures in column of E-2 in sheet of SB & BC to be checked	To check & revise if necessary
4	CP	SG	Table 11-1	Frequency of FDT for embankment (5 locations/2000m3) to be checked	To review & revise if necessary
5	CP	SG	Clause 4.2	Table 3-1 in the clause is not appeared. Table to be incorporated	To review & incorporate if necessary
6	Expert	RG	Clause 9.6	Work execution plan to be stated in RG (method statement to be revised)	To revise
7	CP	SG	Appendix	Material test forms to be incorporated in Appendix	To check & incorporate
8	Expert / CPs	RG	Annex A	Form of contract to be revised in accordance with current contract agreement	To review & revise
9	CP	RG	Annex A	Sub-National Public Infrastructure and Engineering Department (SPIED) established last year will be a Party C and SPIED has to be included in Party C.	To incorporate SPIED as Party C and add SPIED in appropriate parts in RG & SG
10	CP	RG	Annex A	Party B scope shall be stated in form of contract.	To stipulate in clause 3
11	Party B	SG	Clause 11.1.3	The way of thickness control Table 11-2 is no clear.	To add sentence to describe the method of thickness control
12	Party B	SG	Clause 11.1.3	The way of filling of as-built record form in Appendix A is not clear on deviation from the tolerances.	To add sentence to describe how to fill and use the form.
13	Party B	SG	Appendix A	The way of filling of measuring person and witness in Appendix A is not clear.	To inset (name / signature) next to measuring person and witness in Appendix A
14	CP	SG	Table 4-2	Work code is not updated.	To be replaced by updated one
15	CP	SG	Figure 11-1	The figure is not updated.	To add check list

2.5 Authorization of Second Edition of SG / RG

On August 16, 2012 the management meeting was held and second edition of SG / RG was presented by C/P together with other topics to be discussed in the JCC meeting at the end of August 2012. In the meeting, the Project Director H.E. Kem Borey pointed out that certificate for completion issued by Party C (which was lately introduced to implement in force account project) had to be stipulated in the Regulation. This practice was commenced this year and brief of procedure is as follows.

1) Party B shall request Party C check and review the Works when the Works are complete.
2) Party C shall check the site and review the completion documents.
3) Party C shall issue certificate for completion or notify Party B rejection of request , giving reasons.
4) When issuing certificate for completion, Party C shall deliver the certificate to Party D for final inspection.
5) Party D shall inspect the Works and inform Party B and C that either the Works are in order or re-inspection shall be carried out.

This process tends to load heavier responsibility to Party C for managing projects and requires Party C to have regular inspection during the Works for witness. This is the intention of MPWT for force account projects that Party C shall take main roles for not only quality control but also management of construction. The project team made additional sentence in Clause 9.10 of the RG for this newly introduced practice.

At the JCC meeting held on August 30, 2012, the second edition of SG / RG was presented to all member of JCC and then discussed. Eventually the second edition was authorized and decided to issue the Prakas (Ministerial Ordinance) in due course in order to apply the second edition of SG / RG (enclosed in Appendix 2) to construction works to be conducted by DPWTs and other organizations. MPWT confirmed to have intention to apply the SG / RG to at least one project in all 24 provinces and to expand the application of SG / RG to all force account projects in future.
A few members of JCC commented at the meeting that some words in Khmer version of SG / RG had to be checked further and recommended to formulate committee for translation of technical words to Khmer language. A committee for translation to Khmer language may be considered to set up.

The SG / RG has been printed and bound within the Project period, combining the Prakas and delivered to MPWT, 24 DPWTs and other organizations.

2.6 Pilot Project

2.6.1 Selection of Pilot Project in Year 2010

Objectives and selection of pilot projects in 2010 is stipulated below.

- Objectives
  (1) To observe actual performance on several force account projects
  (2) To compare construction management in pilot projects with draft version of the SG and RG
  (3) To appraise performance at completion in different provinces for comparison and future improvement
- Selection of project sites
  After discussing in the C/P meetings and management meetings in May and June 2010, the following projects were selected as pilot projects in 2010.

Table 2.6-1 Selection of Pilot Project in Year 2010

item	Kandal			Kampong Cham	Pursat
Project location	Provincial Road 118 Package 1	Provincial Road 118 Package 2	Provincial Road 118 Package 3	National Road 7	Provincial Road 155
Project scope	Road Widening and DBST length 5.0 km width 7.0 m pavement DBST bridge 12 nos (length 246 m)	Road Widening and DBST length 5.0 km width 7.0 m pavement DBST bridge 3 nos (length 60 m)	Road Widening / Construction and DBST length 5.4 km width 7.0 m pavement DBST bridge 7 nos (length 102 m)	Road Repairing length 2.8 km (out of 90 km) (7 locations) width 9.0 m pavement DBST	Road Repairing length 6.0 km width 6.0 m pavement DBST
Party B	RID Road/Bridge unit	Kandal DPWT	HEC	Kampong Cham DPWT	Pursat DPWT
Party C	RID	RID	PWRC	RID	RID

2.6.2 Implementation of Pilot Project in Year 2010

After selected the pilot projects, project site visits were done several times to observe what had been carried out on site. Schedule of site visits are shown in Table 2.6-2 below.

Table 2.6-2 Schedule of Site Visit in Year 2010

item	Kandal			Kampong Cham	Pursat
Project location	Provincial Road 118 Package 1	Provincial Road 118 Package 2	Provincial Road 118 Package 3	National Road 7	Provincial Road 155
(1) Preliminary visit	date: June 05 observers: experts C/Ps with two staff project side: p. manager & staff	date: June 05 observers: experts C/Ps with two staff project side: deputy director & staff	date: June 05 observers: experts C/Ps with two staff project side: -	-	-
(2) First visit	-	date: July 08 observers: experts C/Ps project side: deputy director & staff observation ・contract not signed yet ・no quality record	-	date: June 30 observers: experts C/Ps project side: director deputy director observation ・works nearly complete ・daily quality record not kept	date: July 6 & 7 observers: experts C/Ps project side: director deputy director observation ・daily quality record not kept
(3) Second visit	date: August 20 observers: experts C/Ps project side: p. manager observation ・contract not signed yet ・appraisal	date: August 19 observers: experts C/Ps project side: deputy director & staff observation ・contract not signed yet ・appraisal	date: August 17 observers: experts C/Ps project side: p. manager observation ・contract not signed yet ・appraisal	date: August 18 observers: experts C/Ps project side: director deputy director observation ・final inspection complete ・appraisal	-

2.6.3 Appraisal of Pilot Project in Year 2010

In order to make comparison and to confirm improvement of pilot projects in views of quality control and construction management carried out in year 2010, 2011 and 2012, appraisal to each project was planned to do. Taking the essence of SG / RG into consideration, the followings were selected for items to appraise.

- Contract: whether staff assigned in the project understands the contents of contract and contract documents are kept on site.
- Plan: whether construction plan and quality control plan (i.e. work execution plan) are prepared in writing and made known to staff assigned in the project.
- Quality control: whether tests (material and field tests) required in the SG are being carried

out and results are being confirmed within tolerance, and
whether tests are being witnessed and records are kept in files

- Schedule control: whether overall and more detail (monthly) schedules are prepared and reviewed regularly with actual progress, and
  whether progress is grasped every month.
- Other documents: whether monthly reports and minutes of meeting are prepared and submitted to Party C.
- Inspection: whether PEAC inspections are done timely prior to contract and during and after implementation.
  (This item was deleted in appraisal for pilot projects in year 2011 and 2012, because these inspections would not be fully done within the SCQC Project and considered not as relevant as other items in views of quality control and construction management.)

For appraisal, each item is evaluated in five grade (1 is worst, 5 is best and minimum acceptance score is 3) and overall score is computed as an average in all evaluated items.

As stated in Section 2.6.1, pilot projects in year 2010 were carried out without applying SG / RG and the appraisals mean to be base figure, representing status of practice at the time for force account project in terms of quality control and construction management.

Details of appraisal are shown in Table 2.6-3 to Table 2.6-6. The scores are between 2.3 to 2.6, which means quality control and construction management was not recognized to be done fully and hence there might have some defects in construction.

Table 2.6-3 Appraisal for Pilot Project in 2010 - 1 -

Project Name: Provincial Road 118 Package 1 Road Expansion & DBST Pavement
Date of Observation / Check: August 20, 2010
Person to Interview: Klaing Sokhoeun (Project Manager, Deputy Chief of Road Unit RID)
Observed / Checked by Yumita, Yamauchi, Sinaveth

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract is still under negotiation. Contract documents are not usually kept on site*	-	
	specification	*Compact Construction Materials Specification in 2010*	*4*	
	bill of quantities	*BQ is not finalized yet. BQ are not usually kept on site.*	*2*	*To keep on site*
	drawings	*Alignment & typical section (designed by road unit) are kept on site.*	*4*	
plans	construction plan	*There is no written plan.*	*1*	*To be in writing*
	quality control plan	*There is no written plan.*	*1*	*Ditto*
	others	-	-	
quality control	material tests	*Laterite, SB, BC, aggregates for DBST were tested in laboratory and are kept on site.*	*4*	
	daily tests	*Field density tests (FDT) and proof rolling tests were carried out regularly. No records except FDT by laboratory were checked.*	*3*	*Record to be kept on site*
	tolerance check	*PM memorized criteria of FDT for laterite, SB and BS.*	*3*	
	inspection	*Full time inspector from RID has been on site. Engineer came once in a month.*	*3*	*Witness records to be prepared.*
schedule control	overall schedule	*Overall schedule is kept on site. More detailed schedule is also kept.*	*3*	
	monthly schedule	*Actual records (when start and complete) have been kept in PM note.*	*2*	*To be formatted*
	current progress	*Road has been complete except those near bridges.*	*3*	
other documents	monthly report	*Report to road unit every week. Monthly report has been also submitted to Road unit.*	*2*	*To be to party C*
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-	-	
inspection	prior to contract	*PEAC inspected in January and February 2010.*	*3*	*No record*
	intermediate 1	*No inspection because of no contract.*	*2*	
	intermediate 2	-	-	
	completion	*No inspection because not complete yet*	-	
	final	-	-	
	others	-	-	
Average score (42 / 16)		*Contract is not finalized, which lowers the score.*	*2.6*	

Table 2.6-4 Appraisal for Pilot Project in 2010 - 2 -

Project Name: Provincial Road 118 Package 2 Road Expansion & DBST Pavement Date of Observation / Check: August 19, 2010

Person to Interview: On Raksmey & Sou Tiro (DPWT Deputy Director), Khiev Sreng (Site Manager) Observed / Checked by Yumita, Yamauchi, Sinaveth

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract is still under negotiation. Contract documents are not usually kept on site.*	-	
	specification	*Construction Specification in 2003. Specification is not on site but kept in DPWT.*	*2*	*To keep on site*
	bill of quantities	*BQ is not finalized yet. BQ are not usually kept on site.*	*2*	*To keep on site*
	drawings	*Alignment & typical section (designed by road unit) and bridge drawings (by RID) are kept on site.*	*4*	
plans	construction plan	*There is no written plan. Before works, plans are discussed in the meeting.*	*2*	*To be in writing*
	quality control plan	*There is no written plan.*	*1*	*Ditto*
	others	-	-	
quality control	material tests	*Laterite, SB, BC, aggregates for DBST were tested in laboratory..*	*3*	*Records to be kept on site*
	daily tests	*Field density tests (FDT) were carried out regularly twice in a month by laboratory.*	*3*	
	tolerance check	*Not memorized*	*1*	
	inspection	*Full time inspector from RID has been on site. Engineer came once in a month.*	*3*	*Witness records to be prepared.*
schedule control	overall schedule	*There is overall schedule.*	*3*	
	monthly schedule	*There is no monthly schedule.*	*1*	
	current progress	*Progress is about 80 %.*	*3*	
other documents	monthly report	*Monthly reports have been submitted to RID & DPWT.*	*2*	*To be formatted*
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-		
inspection	prior to contract	*PEAC inspected before works started.*	*3*	*No record*
	intermediate 1	*No inspection because of no contract.*	*2*	
	intermediate 2	-	-	
	completion	*No inspection because not complete yet*	-	
	final	-	-	
	others	-	-	
Average score (37 / 16)		*Contract is not finalized, which lowers the score.*	*2.3*	

Table 2.6-5 Appraisal for Pilot Project in 2010 - 3 -

Project Name: Provincial Road 118 Package 3 Road Expansion & DBST Pavement
Date of Observation / Check: August 17, 2010
Person to Interview: You Narith (Project Manager, HEC)
Observed / Checked by Yumita, Yamauchi, Kry Thong

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract is still under negotiation.*	-	
	specification	*Construction Specification in 2003.*	*3*	
	bill of quantities	*BQ is being discussed with MEF and not finalized yet.*	*2*	*To keep on site*
	drawings	*Alignment & typical section and bridge drawings (designed by HEC) are kept on site. Pile length was determined based on soil investigation.*	*4*	
plans	construction plan	*There is no written plan.*	*1*	*To be in writing*
	quality control plan	*There is no written plan.*	*1*	*Ditto*
	others	-	-	
quality control	material tests	*Laterite, SB, BC, aggregates for DBST were tested in laboratory..*	*3*	*Records to be kept on site*
	daily tests	*Field density tests (FDT) were carried out regularly by Party B & labo.*	*4*	
	tolerance check	*Earthwork density more than 90%, SB 95% and BS 98 %*	*3*	
	inspection	*Inspector / Engineer from PWRC have been on site only once in a month.*	*2*	*Witness records to be prepared.*
schedule control	overall schedule	*There is overall schedule.*	*3*	
	monthly schedule	*There is no monthly schedule.*	*1*	
	current progress	*Progress is about 70 %.*	*3*	
other documents	monthly report	*Monthly reports have been submitted to HEC and after compiling all projects to GDPW & PWRC.*	*3*	
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-		
inspection	prior to contract	*Do not know.*	-	*No record*
	intermediate 1	*No inspection because of no contract.*	*2*	
	intermediate 2	-	-	
	completion	*No inspection because not complete yet*	-	
	final	-	-	
	others	-	-	
Average score (37 / 15)		*Contract is not finalized and inspector is not full time, which lower the score.*	*2.5*	

Table 2.6-6 Appraisal for Pilot Project in 2010 - 4 -

Project Name: National Road 7 Road Repair with DBST — Date of Observation / Check: August 18, 2010

Person to Interview: Sok Srun (Kampong Cham Director), Chan Somordy (Deputy Director) — Observed / Checked by Yumita, Yamauchi, Sinaveth

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract has been kept in DPWT.*	*2*	*To keep on site*
	specification	*Compact Construction Materials Specification in 2010*	*3*	
	bill of quantities	*BQ has been included in the contract and kept in DPWT.*	*2*	
	drawings	*Drawings have been included in the contract and kept in DPWT.*	*3*	
plans	construction plan	*There is no written plan. Before works, discussions were carried out.*	*2*	*To be in writing*
	quality control plan	*There is no written plan. Before works, discussions were carried out.*	*2*	*Ditto*
	others	-	-	
quality control	material tests	*Laterite, SB, BC, aggregates for DBST were tested in laboratory..*	*3*	*Records to be kept on site*
	daily tests	*Field density tests (FDT) were carried out by laboratory & DPWT. Records carried out by DPWT are not properly kept.*	*3*	
	tolerance check	*Site engineer know them.*	*3*	
	inspection	*Inspector / Engineer from RID have been on site once in a month.*	*2*	*Witness records to be kept.*
schedule control	overall schedule	*There is overall schedule.*	*3*	
	monthly schedule	*Reports to Director in each 10 days.*	*2*	
	current progress	*Completed.*	*3*	
other documents	monthly report	*Monthly reports have been submitted to RID.*	*3*	
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-		
inspection	prior to contract	*PEAC inspected before start*	*3*	*No record*
	intermediate 1	*No inspection*	-	
	intermediate 2	*Ditto*	-	
	completion	*PEAC inspected on July 14 '10, after submitting the report, which received from director.*	*4*	
	final	-	-	
	others	-	-	
Average score (45 / 17)		*QC records have been arranged in the report at completion.*	*2.6*	

2.6.4 Selection of Pilot Project in Year 2011

Besides the site inspections in May and June 2010, further site inspections with C/Ps were conducted for selection of pilot projects for year 2011 in September and October 2010 based on the recommendation from the directors in MPWT. After visiting the possible pilot project sites, the following projects were proposed accordingly as of October 2010.

Table 2.6-7 List of Proposed Pilot Projects

Party B	Party C	Proposed Project
RID	PWRC	**NR 122**
HEC	RID	**NR 53**
DPWT (Kampong Cham)	RID	**NR 73**
DPWT (Kandal)	PWRC	**NR 110**

Then, MPWT discussed with MEF for several times to select the pilot projects during November 2010 to January 2011. Status at the time is shown in Table 2.6-8.

Table 2.6-8 Status of Pilot Project as of January 2011

Location	Road 122	Road 53→Road51	Road 73→71or72	Road 110
Party A	Director General of Public Works			
Party B	RID	HEC	DPWT (Kampong Cham)	DPWT (Kandal)
Party C	PWRC	RID	RID	PWRC
Party D	PEAC, GI			
Final Status	This was ruled out from the list upon discussion with MEF	Road 53 was ruled out, and instead, 51 was recommended. But the scope of work is too small for pilot project.	Road 73 was already done & ruled out. 71 was inspected instead.	OK
Judgment	Ruled out	Ruled out	Road 71 is recommended.	Recommended

The project team evaluated and recommended finally as follows.

<Road 122>
Road 122 project was ruled out from the list of the projects for 2011 budget.

<Road 53>
Road 53 project was ruled out from the list of the projects for 2011 budget and road 51 was recommended instead. However, the project team found it too small for pilot projects, because this project consisted of cutting and patching up in only small defect sections. Table 2.6-9 below shows the evaluation.

<Road 73>
Road 73 project was ruled out from the list of the projects for 2011 budget and road 71 was recommended instead. The project team inspected this site and found it proper for pilot project site. Table 2.6-9 below shows the evaluation.

<Road 110>
This was approved by MEF.

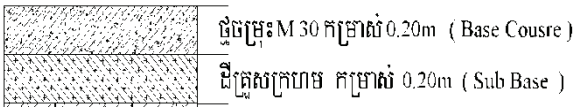
Table 2.6-9 Results of Evaluation for Pilot Projects in Year 2011

		Road 53		Road 71	
Evaluation Items		Rating			
Work Item	Embankment	-	fair	-	fair
	Sub-grade	-		-	
	Sub-base Course	✓		✓	
	Base Course	✓		✓	
	DBST	✓		✓	
Scale of work		Small		Appropriate	
Obstruction		Minimal		Minimal	
Accessibility		Not far		Not far	
Final Rating		fair		good	

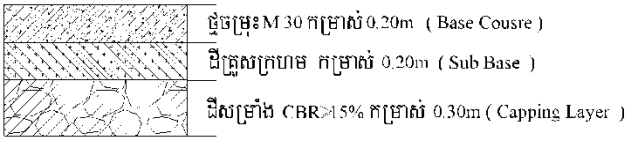
Due to the insufficient budget or scale of work items, the project team recommended two sites for pilot project in year 2011. RID and HEC which had been expected to be Party B were not selected, so that the project team considered that they might participate as Party C. This direction for selection was confirmed by the C/P meeting in January 2011. The Road 71 & 110 projects were agreed and approved for the pilot project in year 2011 in the management meeting in February 2011.

2.6.5 Implementation of Pilot Project in Year 2011

The cost of each pilot project estimated by Party B exceeded the budget assured in 2011, because the work amount became larger as a result of the detailed design. It was found that the CBR value at the detailed design stage was lower than the one at the basic design stage. Therefore, a capping layer had to be added under the sub-base layer to cover the gap in the detailed design. After some negotiations between MEF and MPWT, MEF accepted MPWT's proposal for cost increase of each pilot project to some extent. Figure 2.6-1 shows the comparison of road structures between the basic design and the detailed design.



[Road Structure of Basic Design]



[Road Structure of Detailed Design]

Figure 2.6-1 Comparison between Road Structures

Actually, commencement of the works was delayed for about half a year due to the reasons below.

- Conducting detailed survey and detailed design in the implementation stage in accordance with the SG was the first experience for MPWT / DPWT.
- Quantity of the works (capping layer) increased as a result of the detailed design.
- Total budget confirmation for the force account projects for year 2011 was finalized very late due to negotiation with MEF to be taken much more time than ordinary year.

- Negotiation between MEF and MPWT was a challenge.
- The rainy season which extends from July to October is not appropriate for executing works.
- Even after the rainy season the water level of the road side of Road 110 was so high that the work could not start, resulted from unusual rainfall in 2011.
- Road Asset Management Project (RAMP) aided by World Bank etc. selected the subject road for rehabilitation in part of Road 71 so that MPWT should resolve it before commencement of work.

Finally the works of Road 71 in Kampong Cham commenced in October 2011 and those of Road 110 in Kandal in February 2012.

The schedules of both pilot projects are shown in Figure 2.6-2.

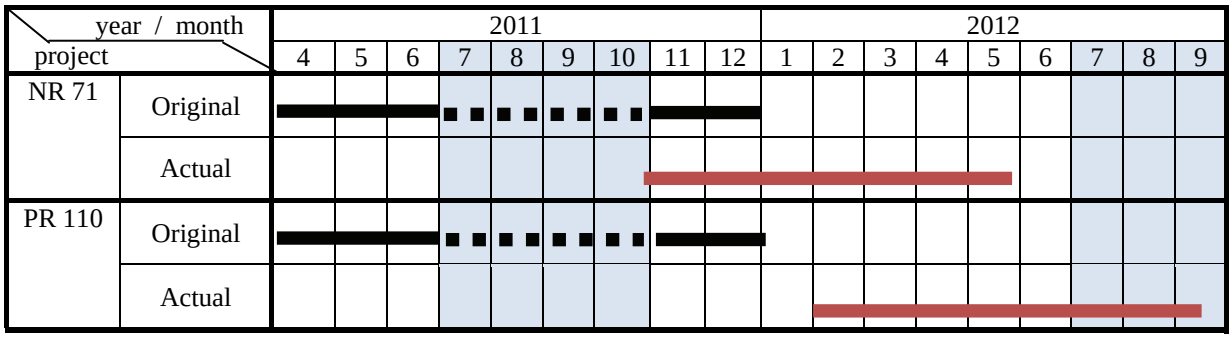


Figure 2.6-2 Schedule of Pilot Project

After commencing the pilot projects, project sites were visited several times to observe what had been carried out on site and to direct what should be done for quality control. Schedule of site visits are shown in Table 2.6-10 below.

Table 2.6-10 Schedule of Site Visit in Year 2011

item	Kampong Cham	Kandal
Project location	National Road 71	Provincial Road 110
(1)	date: November 16, 2011 observers: expert & C/Ps project side: Party B directions ・ Request to tests for quality	Works not commenced yet
(2)	date: December 14, 2011 observers: experts, C/Ps & Party C JICA review team project side: Party B directions ・ Monthly report received ・ Request to follow SG for quality control	ditto
(3)	date: February 16, 2012 observers: experts, C/Ps & Party C project side: Party B directions ・ Request to keep QC record	date: February 17, 2012 observers: experts & Party C project side: Party B directions ・ Confirm contract signed in November ・ Request to keep quality records

item	Kampong Cham	Kandal
(4)	date: April 25, 2012 observers: experts, C/P & Party C project side: Party B directions ・ Work execution plan not completed ・ Improve QC record ・ Confirm contract signed in March	date: April 27, 2012 observers: experts & Party C project side: Party B directions ・ Work execution plan not completed ・ Improve QC record ・ Request schedule control
(5)	date: May 11, 2012 observers: experts, C/Ps & Party C project side: Party B directions ・ Explain completion documents to submit	date: May 10, 2012 observers: experts & Party C project side: Party B directions ・ Check method of proof rolling and field density test
(6)	date: June 14, 2012 observers: experts, C/Ps & Party C project side: Party B directions ・ Request to improve completion documents	-
(7)	date: July 9, 2012 observers: experts & Party C project side: Party B directions ・ Appraisal	date: July 13, 2012 observers: experts & Party C project side: Party B directions ・ Check capping layer material visually
(8)	-	date: August 20, 2012 observers: experts & Party C project side: Party B directions ・ Appraisal ・ Use QC forms properly (witness, elevation, frequency, etc) ・ Unsuitable materials shall be removed from the spreading materials

2.6.6 Appraisal of Pilot Project in Year 2011

Appraisals were carried out to both pilot projects at completion and nearly completion, using the same format explained in the Section 2.6.3. The project for Road 71 in Kampong Cham was appraised in July 2012, whereas that for Road 110 in Kandal was appraised in August 2012.

The score for Road 71 was 4.1 and for 110 was 3.7 respectively and both were very much improved from the base figure (score of pilot project in year 2010), particularly in items of contract, plan, quality control and schedule control. This is considered the results of SG / RG application to the projects as well as numerous site visits by JICA experts, C/Ps and Party C for assistance and guidance in terms of quality control and construction management.

Details of appraisal to both projects are shown in Table 2.6-11 and 2.6-12.

Table 2.6-11 Appraisal for Pilot Project in 2011 - 1 -

Project Name: National Road 71 Road Expansion & DBST Pavement
Date of Observation / Check: July 09, 2012
Person to Interview: Chan Somordy (Project Manager, Deputy Director of Kampong Cham DPWT)
Observed / Checked by Maeda, Noda, Manith

items		comments	evaluation (5grade)	remarks
contract	contract document	*Contract documents are kept on site*	5	
	specification	*Compact Construction Materials Specification in 2011*	5	
	bill of quantities	*BQ is kept on site.*	5	
	drawing	*Alignment & typical section (designed by themself) are kept on site.*	5	
plans	construction plan	*There is written plan.*	*5*	
	quality control plan	*Work execution plan include quality control plan but quantity not written*	*4*	Add additional column
	others	*Plan includes safety management*	*3*	
quality control	material tests	*Laterite, capping layer ,SB, BC, aggregates for DBST were tested in laboratory .Sample not kept on site.*	*4*	Keep sample in site
	daily tests	*Field density tests (FDT) and proof rolling tests were carried out regularly with sign of tester and inspector.*	*5*	
	tolerance check	*As build measuring record not followed specification.*	*3*	Keep final record
	inspection	*Inspector is not full time. Engineer came once in a month.*	*2*	
schedule control	overall schedule	*Overall schedule is kept on site. More detailed schedule is also kept.*	*5*	
	monthly schedule	*Actual records (when start and complete) have been kept in PM note and formatted.*	*5*	
	current progress	*Road has been completed.*	*4*	
other documents	monthly report	*Monthly report has been also submitted to Party C but without as-build measuring*	*3*	
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*3*	
	others	-	-	
Average score (66 / 16)			*4.1*	

Table 2.6-12 Appraisal for Pilot Project in 2011 - 2 -

Project Name: Provincial Road 110 Road Expansion & DBST Pavement — Date of Observation / Check: August 20, 2012

Person to Interview: Kandal DPWT Deputy Director (Mr. On Raksmey, Mr.Vong Dareth, Mr.Hem Somon) — Observed / Checked by Noda, Rethy

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract documents are kept in the Office.*	*4*	
	specification	*They are aware of SG & RG and Construction Specification. Those documents are being carried by them.*	*5*	
	bill of quantities	*BQ is kept in the Office. They know BQ very well.*	*5*	
	drawings	*Alignment & typical section (designed by road unit) are kept on site.*	*5*	
plans	construction plan	*Preparation is on-going*	*2*	
	quality control plan	*Preparation is on-going*	*2*	*To be in writing*
	others		-	
quality control	material tests	*All the material tests have been tested and the records have been kept in the office*	*4*	
	daily tests	*Field density tests (FDT) and proof rolling tests were carried out regularly.*	*5*	
	tolerance check	*As-built measurement inspections were conducted and the forms were filled in. Improvement of the as-built form has been instructed.*	*4*	*To be improved*
	inspection	*Full time inspector has not been assigned.*	*3*	*To be continued*
schedule control	overall schedule	*Overall schedule is kept in the office.*	*4*	
	monthly schedule	*Monthly schedule has been prepared. It has been placed in the monthly report.*	*4*	
	current progress	*It has been shown in the monthly report.*	*4*	
other documents	monthly report	*Monthly report has been prepared since Feb. 2012.*	*3*	*To be continued*
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-	-	
Average score (56 / 15)			*3.7*	

Project at Completion

Appraisal in July 2012

Photo 2.6-1 Pilot Project (Road 71) in Kampong Cham

Completed Capping Layer

Base-course

Photo 2.6-2 Pilot Project (Road 110) in Kandal

2.6.7 Selection of Pilot Project in Year 2012

Concepts for selecting pilot projects for year 2012 were supposed below in second half of 2011.

- Party B shall be same as the ones for the pilot projects in 2011, because they learned what shall be improved in preparations for project.
- A bridge construction project shall be included in the pilot project, because there is not bridge construction in the pilot project in 2011. The proposed standard drawings may be applied to the pilot project.

The project team suggested from the lessons of the pilot project in 2011 that either soil investigations should be conducted to design and estimate the budget for the pilot project in 2012 by early 2012 or Party B should follow the Table 4-1 of SG in basic design and reflect it to design and cost estimation.

Figure 2.6-3 (next page) shows the recommended procedure of pilot project for 2012.

With the consideration mentioned above, the RID proposed projects for the pilot project for 2012 in response to a request from the project team as shown in Table 2.6-13.

Table 2.6-13 Candidate Projects for the Pilot Project in 2012

	Work Scope	Estimated Budget
Road		
Kampong Cham		
NR 70	L=3.0 km, W=7 m, DBST	1,764.0 mil. Riels
PR 270	L=8.5 km, W=7 m, DBST	6,247.5 mil. Riels
Kandal		
PR 110	L=10.0 km, W=6 m, DBST	13,000.0 mil. Riels
PR 380	L=12.0 km, W=7 m, DBST	8,000.0 mil. Riels
Bridge		
Bridge Unit		
Bridge on NR11	L=45 m, W=10 m, RCB	2,362.5 mil. Riels
Bridge on NR11	L=90 m, W=10 m, RCB	4,536.0 mil. Riels

Programe of Pilot Project 2012

a) Schedule

<target schedule>

<Sepember 2011>	<October 2011>	<November 2011>	<November 2011>	<December 2011>	<January 2012>	<February 2012>	<February 2012>	<March 2012>	<March 2012>
1 Selection of Project	2 Basic Survey & Design	3 Cost Estimate	4 Consultation with MEF	5 Budget Confirmation	6 Detail Survey & Design	7 Cost Estimate	8 Consultation with MEF	9 Negotiation with PEAC	10 Contract

<actual schedule>

<September 2011>

Projects shall be commenced in March 2012 and complete by September 2012

b) Selection of Project

1. To select three projects listed under Chapter 61
2. To select projects as follows
   - Road project planned to carry out in Kandal Province
   - Road project planned to carry out in Kampong Cham Province
   - Bridge project planned to carry out in road 11 or road 2 by Bridge unit

c) Issues to be taken care

1. Items 2. Basic Survey & Design and 3. Cost Estimate shall be done by Party B with either a) or b) below.

a) to carry out preliminary sub-grade investigation in basic survey & reflect it to basic design and cost estimation in item 2 & 3
b) to follow the Table 4-1 of SG in basic design and reflect it to basic design and cost estimation in item 2 & 3

2. Basic Survey & Design and Cost Estimate by Party B shall be reviewed and approved by Party C.
3. Party C shall estimate cost for supervision (Party C) and consult & agree it with MEF.
4. Party B shall prepare construction plan, describing kinds of tests & frequency of tests for quality control and providing formats for records of quality tests.
5. Project team shall specify roles of Party D (PEAC / GDI) clearly.

Procedure of Basic Design and Detal Design in Standard Guideline (SG)

a) In basic design (item 2), SG recommends to adopt the pavement design from the Table 4-1 (P 3)

b) In detail design (item 6), SG recommends to adopt the pavement design from Table 9-1 (P 7)

Figure 2.6-3 Recommended Procedure of Pilot Project in 2012

After discussions with the C/Ps and the management of MPWT, the concept was modified in the early 2012 as follows.

- Two road projects shall be selected near the capital, as those can be taken care more often and easily. Possibly Party B will be the same as the ones for the pilot projects of 2011, because they learned what to be improved in preparations for the project.
- One bridge project shall be included because there has been no major structure in the pilot projects in 2011 and the proposed standard drawings will be ready to apply to pilot project.

After discussing about pilot projects several times among the parties concern, the following pilot projects in year 2012 were chosen in February 2012. Outline of pilot projects is shown in Table 2.6-14.

Table 2.6-14 Outline of Pilot Project in Year 2012

Location	Road 44 (NR 44)	Road 153 (PR 153)	Bridge in Road 11 (NR 11)
Party A	Director General of Public Works		
Party B	DPWT (Kampong Speu)	DPWT (Kampong Chhnang)	Bridge Unit in RID
Party C	RID	PWRC	RID
Party D	PEAC, GI and Project team		
Project Brief	Road length 6 km DBST 7m + Shoulder	Road length 3 km DBST 7m + Shoulder	PK 127+800 Length 30 m (2 span) Width 10 m

2.6.8 Implementation of Pilot Project in Year 2012

After selecting the pilot projects, project sites were visited several times to observe what had been carried out on site and to direct what should be done for quality control. As all Party Bs were new to follow the SG /RG and specially Bridge in Road 11 was new for Party C as well, as bridge construction was not included in the pilot projects in year 2011. In order to carry out bridge construction well, piling works were being incorporated in draft of second edition of SG, which was explained to Party B of Bridge in Road 11 during February to April 2012. Schedule of site visits are shown in Table 2.6-15 below.

Table 2.6-15 Schedule of Site Visit in Year 2012

item	Kampong Speu	Kampong Chhnang	Kampong Cham
Project location	National Road 44	Provincial Road 153	Bridge in Road 11
(1)	date: April 18, 2012 observers: experts, C/Ps & Party C project side: Party B directions ・ Request to review soil test results again	date: May 2, 2012 observers: experts & Party C project side: Party B directions ・ Work execution plan not completed ・ Soil tests are under testing in laboratory.	-

item	Kampong Speu	Kampong Chhnang	Kampong Cham
(2)	date: May 8, 2012 observers: experts, C/Ps & Party C project side: Party B directions ・ Request to add capping layer	-	date: May 10, 2012 observers: expert project side: Party B directions ・ Request QC sheets to prepare
(3)	date: May 22, 2012 observers: expert project side: Party B directions ・ Check borrow pit	-	date: May 17/18 observer: experts & Party C project side: Party B directions ・ Request piling records to keep
(4)	-	-	date: June 29, 2012 observer: experts & Party C project side: Party B directions ・ Confirm progress
(5)	date: July 16, 2012 observers: JICA & experts project side: - observation ・Site suspended	-	date: July 11, 2012 observer: experts & Party C project side: Party B directions ・ Check precast yard
(6)	date: July 23, 2012 observers: experts & Party C project side: Party B directions ・ Work terminated ・ QC record insufficient ・ Appraisal at termination	date: July 18, 2012 observers: experts & Party C project side: Party B directions ・ Not yet start ・ Work execution plan not completed	date: July 23, 2012 observer: experts & Party C project side: Party B directions ・ Confirm work execution plan ・ Appraisal at interim
(7)	-	date: September 06, 2012 observers: experts & Party C project side: Party B directions ・ Sub-grade shall be trimmed according to design elevation	date: August 31, 2012 observers: experts & Party C project side: Party B directions ・ Confirm piling work record

2.6.9 Appraisal of Pilot Project in Year 2012

Appraisals were carried out to all pilot projects at termination or interim stage of the projects, using the same format explained in the Section 2.6.3. The project for Road 44 in Kampong Speu was appraised in July 2012, as the project was terminated due to overlapping to loan project from China. The projects for Road 153 in Kampong Chhnang and Road 11 in Kampong Cham were appraised in July and September 2012 respectively, when progress of both projects was not more than 50 %.

Scores for Road 44, 153 and 11 are 2.8, 2.9 and 3.3 respectively. The scores for the pilot projects in year 2012 are lower than those for pilot projects in year 2011, because the progress was lesser. But those were also improved from the base figure (score of pilot project in year 2010), because of the same reasons stated in Section 2.6.6.

Details of appraisal are shown in Table 2.6-16, Table 2.6-17 and Table 2.6-18. It is to note in this regard that scores of pilot projects in year 2012 (except Road 11) would have been similar to those of pilot projects in year 2011, if appraisals would be done at completion.

It is hoped that all force account projects in future would be appraised in the same manner and have score 4 and above in all items.

Table 2.6-16 Appraisal for Pilot Project in 2012 - 1 -

Project Name: Provincial Road 44 Road Expansion & DBST Pavement
Date of Observation / Check: May 8/July 23, 2012
Person to Interview: Mr. Som Sothea (Project manager)
Observed / Checked by Maeda, Izawa , Onit

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract is still under negotiation. Contract documents are usually kept on site.*	*2*	
	specification	*Compact Specification 2010 keep on site.*	*4*	*To be continued*
	bill of quantities	*BQ is finalized and BQ are kept on site.*	*4*	
	drawings	*Alignment & typical section are kept on site.*	*4*	
plans	construction plan	*There is written plan.*	*5*	
	quality control plan	*There is not written*	*2*	*To be writing*
	others	*Plan without safety management*	*1*	*ditto*
quality control	material tests	*Soil for embankment were tested in laboratory. Borrow pits are doubtable*	*2*	*Borrow pit and quarry map should be attached in test result*
	daily tests	*Field density tests (FDT) were not carried out. Proof rolling were not carried out too.*	*1*	*Party C should point out*
	tolerance check	-	-	
	inspection	-	-	
schedule control	overall schedule	*There is overall schedule.*	*4*	
	monthly schedule	-	-	
	current progress	-	-	
other documents	monthly report	-	-	
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-	-	
Average score (31 / 11)			*2.8*	

Table 2.6-17 Appraisal for Pilot Project in 2012 - 2 -

Project Name: Provincial Road 153 Road Expansion & DBST Pavement
Date of Observation / Check: September 6, 2012
Person to Interview: Mr. YIM VANNA (Deputy Director)
Observed / Checked by Noda, Vesna

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract is still under negotiation. Contract documents are usually kept on site.*	*2*	
	specification	*Standard Guideline and Construction Specification. They are not on site but kept in DPWT.*	*3*	*To carry them*
	bill of quantities	*BQ is not finalized yet.*	*2*	
	drawings	*Alignment, profile & typical section are being carried.*	*5*	
plans	construction plan	*There is written plan in the contract document.*	*3*	
	quality control plan	*There is no written plan*	*1*	*To be writing*
	others	*No safety plan but necessary signboards are properly being placed*	*3*	
quality control	material tests	*Laterite and SB were tested in Laboratory.*	*4*	
	daily tests	*No activities are carried out require daily tests*	-	
	tolerance check	*No activities are carried out require tolerance check*	-	
	inspection	*Inspector are coming when necessary*	*3*	
schedule control	overall schedule	*There is overall schedule.*	*4*	
	monthly schedule	-	-	
	current progress	-	-	
other documents	monthly report	-	-	
	minutes of meeting	*There have been meetings between party B & C. No minutes were taken.*	*2*	*To make minutes*
	others	-	-	
Average score (32 / 11)			*2.9*	

Table 2.6-18 Appraisal for Pilot Project in 2012 - 3 -

Project Name: National Road 11 Bridge Reconstruction — Date of Observation / Check: July 23, 2012

Person to Interview: You Vouthny (Deputy Director of Bridge unit) — Observed / Checked by Izawa, Leng Song, Menakak

Items		Comments	evaluation (5grade)	remarks
contract	contract document	*Contract and Contract document is completed. Contract has been kept in Bridge unit and site.*	*5*	
	specification	*Compact Construction Materials Specification in 2010. But 2nd edition of S/G was applied for piling works as trial.*	*3*	
	bill of quantities	*BQ has been included in the contract and kept in Bridge unit.*	*4*	
	drawings	*Drawings have been included in the contract and kept in Bridge unit.*	*4*	
plans	construction plan	*Work execution plan is completed.*	*4*	
	quality control plan	*It is included in Work execution plan. Before work, several times discussed about quality control to be carried out.*	*3*	
	others		-	
quality control	material tests	*Rebar and Concrete material test was tested in laboratory.*	*4*	
	daily tests	*Daily test (slump, mold for strength test) for every pouring was conducted several times already.*	*3*	
	tolerance check	*Site engineer had measured every size of structure. Documentation is preparing.*	*3*	
	inspection	*Inspector / Engineer from RID have been on site once in a month.*	*2*	
schedule control	overall schedule	*There is overall schedule in work execution plan.*	*4*	
	monthly schedule	*Reports to Director in each 10 days.*	*2*	
	current progress	*Intermediate pier is completed. Both abutments are almost completed, but still preparing to make back wall with approach slab. After erection of girder will be completed of pouring back wall.*	*3*	
other documents	monthly report	*Monthly reports have been submitted to RID.*	*3*	
	minutes of meeting	*There have been meetings between party B & C by phone. No minutes were taken.*	*2*	*To make minutes*
	others	-		
Average score (49 / 15)		*QC records have been arranged in the report at completion.*	*3.3*	

Embankment

Completed Embankment at Termination

Photo 2.6-3 Pilot Project (Road 44) in Kampong Spue

Before Commencement

Just commenced

Photo 2.6-4 Pilot Project (Road 153) in Kampong Chhnang

Piling Works

Appraisal at Interim Stage

Photo 2.6-5 Pilot Project (Bridge in Road 11) in Kampong Cham

2.7 Recommendation for Application of SG / RG to Force Account Projects

(1) Support System to DPWTs for Application of SG / RG to Force Account Projects: After completion of the Project at the end of October 2012, force account projects are still lasting without JICA experts. In the year 2013, at least one project in all provinces was decided to implement with application of SG / RG, which means 20 provinces (other than Kampong Cham, Kandal, Kampong Speu and Kampong Chhnang having experience to carry out the pilot projects) will have first occasion to apply the SG / RG to force account projects. In order to make smooth application of SG / RG to force account projects, appointed Party C needs to lead each and all DPWTs more closely for applying the SG / RG as On the Job Training (OJT).

In addition, support system for construction quality control is recommended to formulate in MPWT by making net-work of the counterparts and the Party B / C within the SCQC Project and to announce the support system to MPWT and all DPWTs, so that DPWTs have an access to the support system to ask questions concerning SG / RG and construction quality control, when they need to have ideas and solutions in this regard. JICA experts may be included in this net-work.

(2) Collection of Completion Documents: Completion documents for the pilot project in National Road 71 implemented by Kampong Cham province in SCQC Project were compiled, delivered to relevant DPWTs for reference and input into the database system (Task 3). Completion documents for other pilot projects (PR 110 by Kandal province, NR 44 by Kampong Spue province, NR 153 by Kampong Chhnang province and Bridge in NR 11 by RID Bridge unit) are recommended to compile and input to the database. If these be done, staff in MPWT and DPWTs will be able to refer past practices and may find out answers to questions any time.

(3) Award System for Force Account Projects: In order to encourage Party B and C, it is recommended that award system for force account project in view of construction quality, safety and timely construction etc. will be formulated. Once such system is introduced, Party B and C may be more motivated and competitive to implement the project with due care to the SG / RG.

(4) Trace through Maintenance Works for Life Cycle Cost: Figure 2.7-1 indicates the schematic comparison of construction and maintenance costs between current practice (blue) and proposal (red, with SG/RG). This means that proposal is more expensive in initial construction, whereas it is less in maintenance cost and thus life cycle cost in proposal may be lesser than that in current practice. It is recommended that the construction and maintenance costs in pilot projects shall be traced and the results of trace may be proof that life cycle cost with SG / RG is lesser than the life cycle cost in current practice.

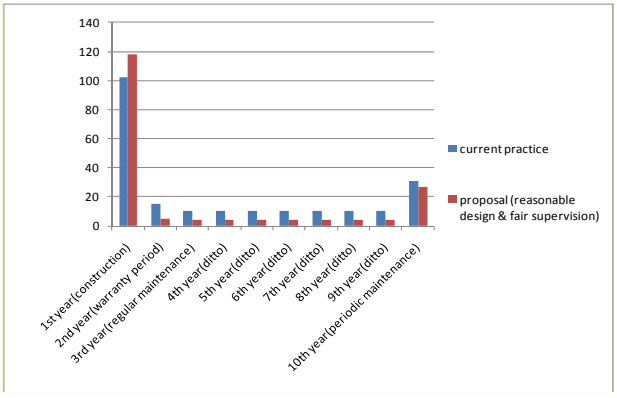


Figure 2.7-1 Comparison of Life Cycle Cost

(5) Update and Upgrade of SG / RG: Latest SG / RG is the second edition compiled in the Project and these kinds of guideline and rule are said in general to be reviewed regularly and updated / upgraded within certain period by incorporating new findings and technologies. Otherwise those will be out of date and deteriorated. It is therefore recommended that ad hoc task force in PWRC of MPWT shall be set up for review of the contents of SG / RG in regular basis, say every three year.

CHAPTER 3 TASK 1-2 STUDY OF APPLICATION OF DISPERSIVE SOIL TO ROAD WORKS

3.1 Brief of Study

3.1.1 Introduction

There exists dispersive soil in flood areas in Cambodia. Dispersive soil has a characteristic of dispersion or erosion by rainfall or flooding water and making holes that is called “Dragon hole” in Cambodia. Dispersive soil has ever been used as one of fill materials for road constructions without confirmation of its possibility of dispersion. Therefore, some road embankments or slopes which might be constructed using dispersive soil has been repeatedly destructed and needed to be repaired.

It has been expected that appropriate treatment of dispersive soil in earthworks is done to ensure high quality road structures.

It is generally said that dispersive soil can be stabilized against water by the soil being mixed with cement, lime or gypsum which contains cations of calcium. In this study, simple dispersion test with which local engineers can easily distinguish dispersive soil was conducted. This study includes simple dispersion tests in laboratory and a pilot work of existing road slope improvement based on the result of laboratory tests.

3.1.2 Methodology

The flow of the study is shown in Figure 3.1-1.

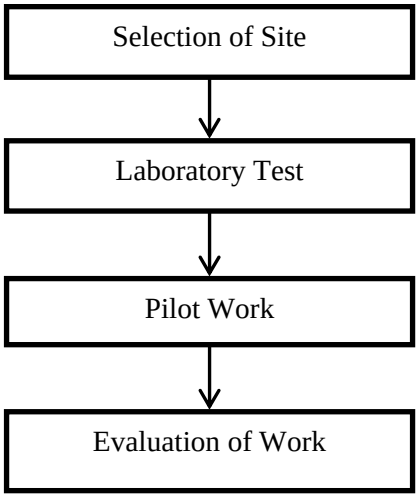


Figure 3.1-1 Flow of Study

3.1.3 Selection of Pilot Work Site

Two candidate sites along National Road (NR) 6 and NR 21 were examined in terms of existent of dragon hole, distance from Phnom Penh, future plan of its improvement. The site on NR 6 was omitted because the road improvement work was planned in year 2012. Finally, the site on NR21 was decided as a pilot work site. Site location map are shown in Figure 3.1-2 and the conditions of the road slope in the site is shown in Figure 3.1-3.

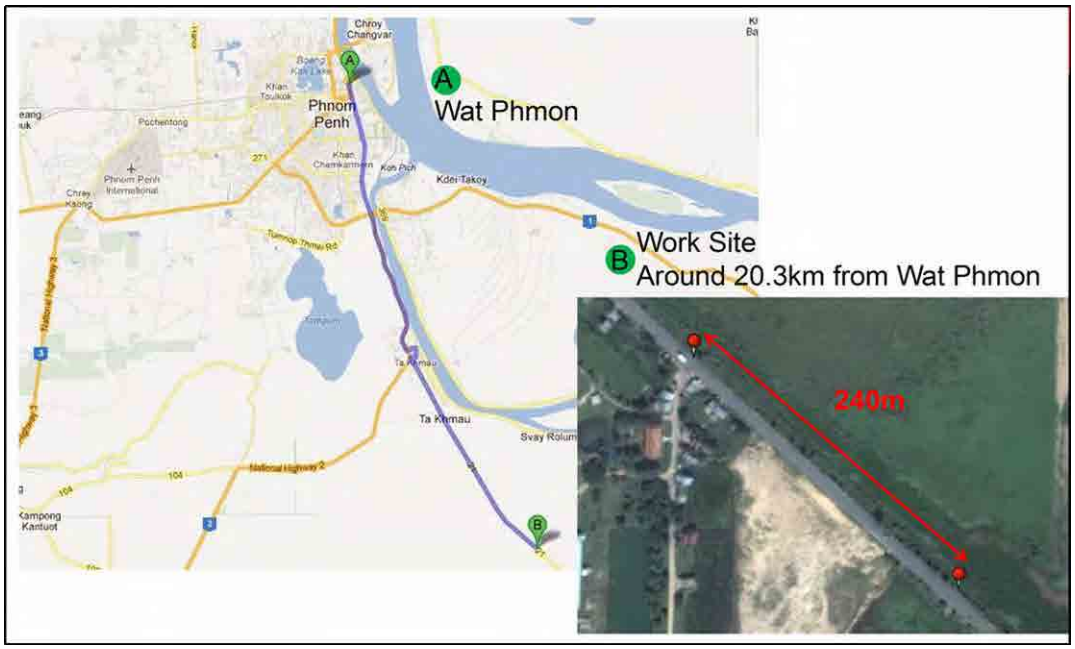


Figure 3.1-2 Site Location of Pilot Work

Distant View

Existent of Dragon Hole

Photo 3.1-1 Conditions of Road Slope on Site

3.2 Laboratory Test

The flow of Laboratory Test is shown in Figure 3.2-1.

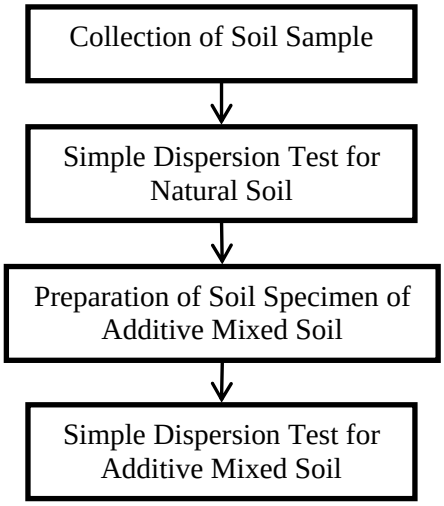


Figure 3.2-1 Flow of Laboratory Test

3.2.1 Test Method

3.2.1.1 Dispersion Test Method for Natural Soil

The process of the test is mentioned below. Pictures of each sample were taken from starting time for 120 minutes at every 10 minutes interval.

1) Soil aggregates are placed into a clear jar of distilled water, taking care not to mix or agitate the soil. This is starting time of a test.
2) Aggregates often (but not always) slake (crumble) soon after being placed in the water, however this is not dispersion.
3) The water around the edges of the soil aggregate in dispersive soils become cloudy and milky looking (water looks dirty) because of the dispersed clay.
4) For a highly dispersive soil dispersion is obvious after about 10-30 minutes, for a moderately dispersive soil it may take two hours for dispersion to be obvious (See Figure3.2-2 Sample of Dispersion).

Figure 3.2-2 Sample of Dispersion

3.2.1.2 Dispersion Test Method for Additive Mixed Soil

(1) Preparing Soil Specimen

Dry unit weight of soil sample selected as sample to be mixed with additives was measured in order to decide additive adding amount to the sample soil according to the planned mixing rate.

Soil specimens were made under the process that mixing additive and soil then adding some water to them to put them together.

(2) Dispersion Test

The method of dispersion test for additive mixed soil is same as the method mentioned in the Section 3.2.1.1. but the word “Aggregate” in the section should be replaced to “Soil Specimen”.

Photographs of preparation of specimen and dispersion test are shown in Photo 3.2-1.

Preparation of Soil Specimen

Dispersion Test

Photo 3.2-1 Photographs of Dispersion Test

3.2.2 Collecting Soil Sample for Test from Site

Dry Soil Aggregates (crumbs of soil) and Mass of Soil were collected at the locations in each section. There are 24 sections in the pilot work site and each section has 3 locations where soil was collected.

Figure 3.2-4 shows the sections and Figure 3.2-5 shows the locations in a section.

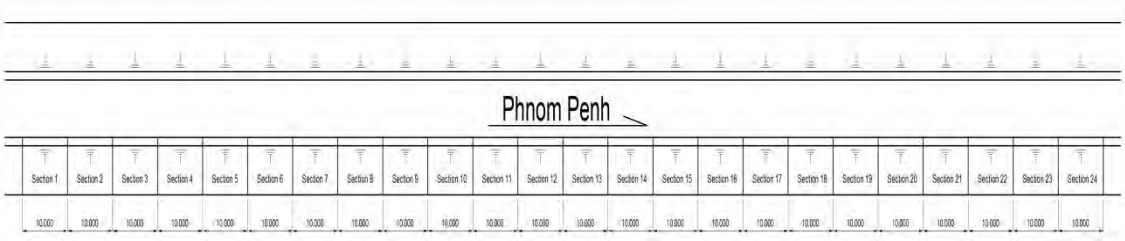


Figure 3.2-3 Sections in Pilot Work Site on NR21

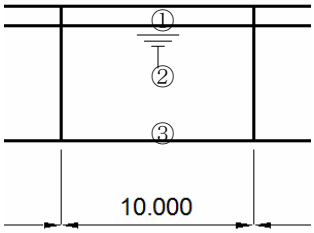


Figure 3.2-4 Locations in a Section for Collecting Soil Sample

Additionally, 3 samples were taken from a borrow pit where the soil for the road embankment at the site was obtained.

Points of Collecting Soil:

-Collected soil does not contain vegetation.
-Crumb of soil is dry.
-A diameter of crumb soil is between 10 mm and 20 mm.
-Crumb of soil is kept in plastic bags.
-Amount of mass of soil is more than 3 litters each.
-Masses of soil is kept in plastic bags.
-Covering soil having been put for slope maintenance on the original slope embankment is not collected.

Photo 3.2-2 shows situation of collecting soil sample at the site.

Collecting soil sample

Gathered samples in plastic bags

Photo 3.2-2 Situation of Collecting Soil Sample

3.2.3 Additives to Dispersive Soil

In order to stabilize dispersive soil against dispersion or dissolve, it is proved that appropriate compaction of embankment only is not enough but adding additives such as lime or cement is efficient. Additives generally used for improvement of dispersive soil mentioned below were used for the test.

Additives used for the test:

Lime, Cement, Gypsum and Fly ash

3.2.4 Test Cases

Simple dispersive soil tests were conducted for both non-improved or natural soil sample and improved or additive mixed soil.

Samples which were added additives were selected based on the results of the test for natural soil sample. Each two samples evaluated as slight, moderate or severe dispersive were selected as representative ones.

Mixing rate of additives were decided as 1, 3, 5or 7 % of dry weight of soil because efficient mixing rate was unknown at the beginning of the test.

Total of 75 samples of natural soil and 96 specimens of additive mixed soil was tested. Test cases of additive mixed soil were shown in Table 3.2-1 together with the test results.

3.2.5 Result of Test

3.2.5.1 Result of Test for Natural Soil

(1) Result of Test

Evaluations about dispersion of all samples of natural soil were distributed as:
Nil : 6 samples,
Slight : 14 samples,
Moderate : 8 samples and
Severe : 47 samples.

69 samples out of 75 sample or 92 % of all samples were evaluated as dispersive but their degrees of dispersion were different. This result refers to the actual condition of the road slope at the site.

For example, Figure 3.2-5 shows the test result of natural soil evaluated as non-dispersive soil. The test results of natural soil evaluated as dispersive soil are shown in Figure 3.2-6 and 3.2-7 together with test results of additive mixed soil.

0 min.	60 min.	120 min.	Evaluation
			Nil

Figure 3.2-5 Test Result of Natural Soil Evaluated as Non-Dispersive Soil

A Summarized table and photographs of the test are attached in the Appendix 3-1 Laboratory Test Result of Natural Soil.

(2) Selection of Representative Soil Sample

Representative soil samples which were to be used for the test for additive mixed soil were selected as follows.

Slight dispersive : Samples of 2-1 and 12-3
Moderate dispersive : Samples of 6-3 and 11-3
Severe dispersive : Samples of 1-1 and 13-1

3.2.5.2 Result of Test for Additive Mixed Soil

After making soil specimen by the way mentioned in the Section 3.2.1.2, dispersion tests were conducted.

The test results show that all Cement, Lime and Gypsum were effective to prevent dispersion. Mixing rate of more than 1% is effective for moderate and slight dispersive soil and more than 3 % is effective for the severe dispersive soil.

However, fly ash deteriorated the intense of dispersion when it was applied to dispersive soil with its mixing rate of under 7 %.

For example, Figure 3.2-6 and 3.2-7 show the test result of additive mixed soil together with the test result of natural soil.

Sample No. 11-3

	0 min.	60 min.	120 min.	Evaluation
Natural soil				Moderate
Cement 1 %				Nil (only slaking)
Fly ash 3 %				Severe
Fly ash 5 %				Moderate
Fly ash 7 %				Slight

Figure 3.2-6 Test Result of Natural Soil and Additive Mixed Soil-1

Sample No. 1-1

	0 min.	60 min.	120 min.	Evaluation
Natural soil				Severe
Cement 1 %				Slight (only non-mixed portion)
Cement 3 %				Nil (only slaking)
Fly ash 7 %				Severe

Figure 3.2-7 Test Result of Natural Soil and Additive Mixed Soil-2

The summary of the result of the tests is shown in Table 3.2-1 and photographs of the test are attached in the Appendix 3-2 Laboratory Test Result of Additive Mixed Soil.

Explanations of "Soil Specimen Name" and "Natural Soil Sample No." in Table 3.2-1 are as follow.

Soil Specimen Name:

A soil specimen additives mixed is named being able to be identified in terms of its original natural soil sample's evaluation, kind of additive and its mixing rate. For example, when the natural soil sample's evaluation of the specimen is moderate, number of the natural soil sample is No.2 of two natural soil samples, its additive is cement and the mixing rate is 5 %, it is named "Moderate-2-C5".

Natural Soil Sample No.:

A natural soil sample was named being able to be identified in terms of its section and location. For example, the sample taken from location ① of section 3 was named as "3-1". When soil sample was taken from borrow pit, letter "B" is used as section number.

Table 3.2-1 Summary of Result of Test for Additive Mixed Soil

Soil Specimen Name	Natural Soil Sample No.	Natural Soil Sample's Evaluation	Additive	Date	Starting Time	Evaluation			
						Nil	Slight	Moderate	Severe
Slight - 1 - C1	2-1	Slight	Cement 1%	Feb. 15, 2012	9:00		✓		
Slight - 1 - C3	2-1	Slight	Cement 3%	Feb. 15, 2012	9:00	✓			
Slight - 1 - C5	2-1	Slight	Cement 5%	Feb. 15, 2012	9:00	✓			
Slight - 1 - C7	2-1	Slight	Cement 7%	Feb. 15, 2012	9:00	✓			
Slight - 1 - L1	2-1	Slight	Lime 1%	Feb. 15, 2012	9:00	✓			
Slight - 1 - L3	2-1	Slight	Lime 3%	Feb. 15, 2012	9:00	✓			
Slight - 1 - L5	2-1	Slight	Lime 5%	Feb. 15, 2012	9:00	✓			
Slight - 1 - L7	2-1	Slight	Lime 7%	Feb. 15, 2012	9:00	✓			
Slight - 1 - G1	2-1	Slight	Gypsum 1%	Feb. 15, 2012	13:00	✓			
Slight - 1 - G3	2-1	Slight	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Slight - 1 - G5	2-1	Slight	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Slight - 1 - G7	2-1	Slight	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Slight - 1 - F1	2-1	Slight	Fly ash 1%	Feb. 15, 2012	13:00				✓
Slight - 1 - F3	2-1	Slight	Fly ash 3%	Feb. 15, 2012	13:00				✓
Slight - 1 - F5	2-1	Slight	Fly ash 5%	Feb. 15, 2012	13:00				✓
Slight - 1 - F7	2-1	Slight	Fly ash 7%	Feb. 15, 2012	13:00				✓
Slight - 2 - C1	12-3	Slight	Cement 1%	Feb. 15, 2012	9:00	✓			
Slight - 2 - C3	12-3	Slight	Cement 3%	Feb. 15, 2012	9:00	✓			
Slight - 2 - C5	12-3	Slight	Cement 5%	Feb. 15, 2012	9:00	✓			
Slight - 2 - C7	12-3	Slight	Cement 7%	Feb. 15, 2012	9:00	✓			
Slight - 2 - L1	12-3	Slight	Lime 1%	Feb. 15, 2012	9:00	✓			
Slight - 2 - L3	12-3	Slight	Lime 3%	Feb. 15, 2012	9:00	✓			
Slight - 2 - L5	12-3	Slight	Lime 5%	Feb. 15, 2012	9:00	✓			
Slight - 2 - L7	12-3	Slight	Lime 7%	Feb. 15, 2012	9:00	✓			
Slight - 2 - G1	12-3	Slight	Gypsum 1%	Feb. 15, 2012	13:00	✓			
Slight - 2 - G3	12-3	Slight	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Slight - 2 - G5	12-3	Slight	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Slight - 2 - G7	12-3	Slight	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Slight - 2 - F1	12-3	Slight	Fly ash 1%	Feb. 15, 2012	13:00			✓	
Slight - 2 - F3	12-3	Slight	Fly ash 3%	Feb. 15, 2012	13:00			✓	
Slight - 2 - F5	12-3	Slight	Fly ash 5%	Feb. 15, 2012	13:00		✓		
Slight - 2 - F7	12-3	Slight	Fly ash 7%	Feb. 15, 2012	13:00		✓		
Moderate - 1 - C1	6-3	Moderate	Cement 1%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - C3	6-3	Moderate	Cement 3%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - C5	6-3	Moderate	Cement 5%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - C7	6-3	Moderate	Cement 7%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - L1	6-3	Moderate	Lime 1%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - L3	6-3	Moderate	Lime 3%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - L5	6-3	Moderate	Lime 5%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - L7	6-3	Moderate	Lime 7%	Feb. 15, 2012	9:00	✓			
Moderate - 1 - G1	6-3	Moderate	Gypsum 1%	Feb. 15, 2012	13:00	✓			

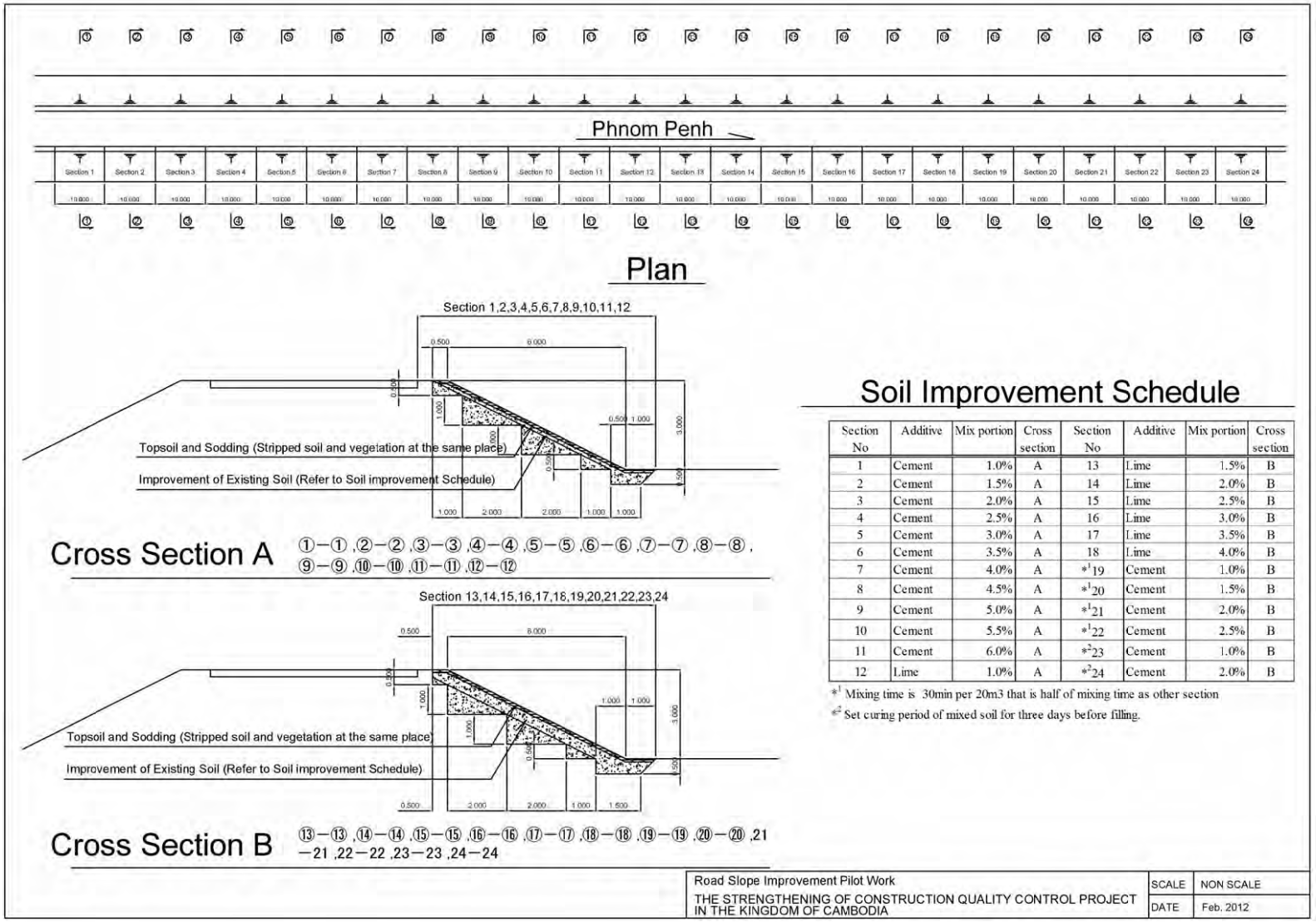
Soil Specimen Name	Natural Soil Sample No.	Natural Soil Sample's Evaluation	Additive	Date	Starting Time	Evaluation			
						Nil	Slight	Moderate	Severe
Moderate - 1 - G3	6-3	Moderate	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - G5	6-3	Moderate	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - G7	6-3	Moderate	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - F1	6-3	Moderate	Fly ash 1%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - F3	6-3	Moderate	Fly ash 3%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - F5	6-3	Moderate	Fly ash 5%	Feb. 15, 2012	13:00	✓			
Moderate - 1 - F7	6-3	Moderate	Fly ash 7%	Feb. 15, 2012	13:00	✓			
Moderate - 2 - C1	11-3	Moderate	Cement 1%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - C3	11-3	Moderate	Cement 3%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - C5	11-3	Moderate	Cement 5%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - C7	11-3	Moderate	Cement 7%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - L1	11-3	Moderate	Lime 1%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - L3	11-3	Moderate	Lime 3%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - L5	11-3	Moderate	Lime 5%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - L7	11-3	Moderate	Lime 7%	Feb. 15, 2012	9:00	✓			
Moderate - 2 - G1	11-3	Moderate	Gypsum 1%	Feb. 15, 2012	13:00	✓			
Moderate - 2 - G3	11-3	Moderate	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Moderate - 2 - G5	11-3	Moderate	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Moderate - 2 - G7	11-3	Moderate	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Moderate - 2 - F1	11-3	Moderate	Fly ash 1%	Feb. 15, 2012	13:00				✓
Moderate - 2 - F3	11-3	Moderate	Fly ash 3%	Feb. 15, 2012	13:00				✓
Moderate - 2 - F5	11-3	Moderate	Fly ash 5%	Feb. 15, 2012	13:00			✓	
Moderate - 2 - F7	11-3	Moderate	Fly ash 7%	Feb. 15, 2012	13:00		✓		
Severe - 1 - C1	1-1	Severe	Cement 1%	Feb. 15, 2012	9:00		✓		
Severe - 1 - C3	1-1	Severe	Cement 3%	Feb. 15, 2012	9:00	✓			
Severe - 1 - C5	1-1	Severe	Cement 5%	Feb. 15, 2012	9:00	✓			
Severe - 1 - C7	1-1	Severe	Cement 7%	Feb. 15, 2012	9:00	✓			
Severe - 1 - L1	1-1	Severe	Lime 1%	Feb. 15, 2012	9:00		✓		
Severe - 1 - L3	1-1	Severe	Lime 3%	Feb. 15, 2012	9:00	✓			
Severe - 1 - L5	1-1	Severe	Lime 5%	Feb. 15, 2012	9:00	✓			
Severe - 1 - L7	1-1	Severe	Lime 7%	Feb. 15, 2012	9:00	✓			
Severe - 1 - G1	1-1	Severe	Gypsum 1%	Feb. 15, 2012	13:00	✓			
Severe - 1 - G3	1-1	Severe	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Severe - 1 - G5	1-1	Severe	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Severe - 1 - G7	1-1	Severe	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Severe - 1 - F1	1-1	Severe	Fly ash 1%	Feb. 15, 2012	13:00				✓
Severe - 1 - F3	1-1	Severe	Fly ash 3%	Feb. 15, 2012	13:00				✓
Severe - 1 - F5	1-1	Severe	Fly ash 5%	Feb. 15, 2012	13:00				✓
Severe - 1 - F7	1-1	Severe	Fly ash 7%	Feb. 15, 2012	13:00				✓
Severe - 2 - C1	13-1	Severe	Cement 1%	Feb. 15, 2012	9:00		✓		
Severe - 2 - C3	13-1	Severe	Cement 3%	Feb. 15, 2012	9:00	✓			
Severe - 2 - C5	13-1	Severe	Cement 5%	Feb. 15, 2012	9:00	✓			

Soil Specimen Name	Natural Soil Sample No.	Natural Soil Sample's Evaluation	Additive	Date	Starting Time	Evaluation			
						Nil	Slight	Moderate	Severe
Severe - 2 - C7	13-1	Severe	Cement 7%	Feb. 15, 2012	9:00	✓			
Severe - 2 - L1	13-1	Severe	Lime 1%	Feb. 15, 2012	9:00	✓			
Severe - 2 - L3	13-1	Severe	Lime 3%	Feb. 15, 2012	9:00	✓			
Severe - 2 - L5	13-1	Severe	Lime 5%	Feb. 15, 2012	9:00	✓			
Severe - 2 - L7	13-1	Severe	Lime 7%	Feb. 15, 2012	9:00	✓			
Severe - 2 - G1	13-1	Severe	Gypsum 1%	Feb. 15, 2012	13:00	✓			
Severe - 2 - G3	13-1	Severe	Gypsum 3%	Feb. 15, 2012	13:00	✓			
Severe - 2 - G5	13-1	Severe	Gypsum 5%	Feb. 15, 2012	13:00	✓			
Severe - 2 - G7	13-1	Severe	Gypsum 7%	Feb. 15, 2012	13:00	✓			
Severe - 2 - F1	13-1	Severe	Fly ash 1%	Feb. 15, 2012	13:00				✓
Severe - 2 - F3	13-1	Severe	Fly ash 3%	Feb. 15, 2012	13:00				✓
Severe - 2 - F5	13-1	Severe	Fly ash 5%	Feb. 15, 2012	13:00				✓
Severe - 2 - F7	13-1	Severe	Fly ash 7%	Feb. 15, 2012	13:00				✓
Total Number						72	7	3	14

3.3 Pilot Work

3.3.1 Work Plan

Taking into consideration of the results of the laboratory test, the work plan of the pilot work was examined. The drawing including plan, cross sections and soil improvement schedule are shown in Figure 3.3-1. The road slope of 240 m along the road was divided into 24 sections. Each section has 10 m long along the road. Technical Specification of Pilot Work including laboratory tests and works is attached in the Appendix 3-5 Technical Specification of Pilot Work.



Section No	Additive	Mix portion	Cross section	Section No	Additive	Mix portion	Cross section
1	Cement	1.0%	A	13	Lime	1.5%	B
2	Cement	1.5%	A	14	Lime	2.0%	B
3	Cement	2.0%	A	15	Lime	2.5%	B
4	Cement	2.5%	A	16	Lime	3.0%	B
5	Cement	3.0%	A	17	Lime	3.5%	B
6	Cement	3.5%	A	18	Lime	4.0%	B
7	Cement	4.0%	A	*1 19	Cement	1.0%	B
8	Cement	4.5%	A	*1 20	Cement	1.5%	B
9	Cement	5.0%	A	*1 21	Cement	2.0%	B
10	Cement	5.5%	A	*1 22	Cement	2.5%	B
11	Cement	6.0%	A	*2 23	Cement	1.0%	B
12	Lime	1.0%	A	*2 24	Cement	2.0%	B

*1 Mixing time is 30min per 20m3 that is half of mixing time as other section

*2 Set curing period of mixed soil for three days before filling.

Figure 3.3-1 Plan and Cross Section of Pilot Work

3.3.1.1 Selection of Kinds of Additive and Its Mixing Rate

Cement and Lime were selected as mixing additive but fly ash which dispersion could not be prevented but even deteriorated with and gypsum which effect was proved but its price is the highest was excluded.

Considering the efficiency of difference between laboratory mixing and site mixing, site mixing rate should be more than that in the laboratory. Cement or lime was ever used as an additive to soil for increasing its strength. In this instance, its site mixing rate is three times more than laboratory mixing rate at which a goal strength can be ensured. However, it is thought that mechanism of improvement for dispersion and improvement for strength are different, so variety of mixing rate was tried at site. Schedule of mixing rate for each section is shown in Table 3.3-1.

Table 3.3-1 Soil Mixing Schedule

Section No	Additive	Mix portion	Cross section	Section No	Additive	Mix portion	Cross section
1	Cement	1.0%	A	13	Lime	1.5%	B
2	Cement	1.5%	A	14	Lime	2.0%	B
3	Cement	2.0%	A	15	Lime	2.5%	B
4	Cement	2.5%	A	16	Lime	3.0%	B
5	Cement	3.0%	A	17	Lime	3.5%	B
6	Cement	3.5%	A	18	Lime	4.0%	B
7	Cement	4.0%	A	*1 19	Cement	1.0%	B
8	Cement	4.5%	A	*1 20	Cement	1.5%	B
9	Cement	5.0%	A	*1 21	Cement	2.0%	B
10	Cement	5.5%	A	*1 22	Cement	2.5%	B
11	Cement	6.0%	A	*2 23	Cement	1.0%	B
12	Lime	1.0%	A	*2 24	Cement	2.0%	B

*1 Mixing time is 30min per 20m3 that is half of mixing time as other section

*2 Set curing period of mixed soil for three days before filling.

3.3.1.2 Thickness of Improved Soil

In order to confirm effective thickness of the improvement, 50 cm or 100 cm in lateral thickness were applied to the work. Refer to Figure 3.3-1.

3.3.1.3 Mixing Soil

Equipment for mixing soil was backhoe. In order to confirm effective mixing time for soil and additives, 30 minutes or 60 minutes for soil of 18 m^3 were applied to the work. Sample photographs of mixing soil are shown in Photo 3.3-1.

Photo 3.3-1 Mixing Soil with Additive

3.3.2 Work Procedure

Work procedure is shown in Figure 3.3-2.

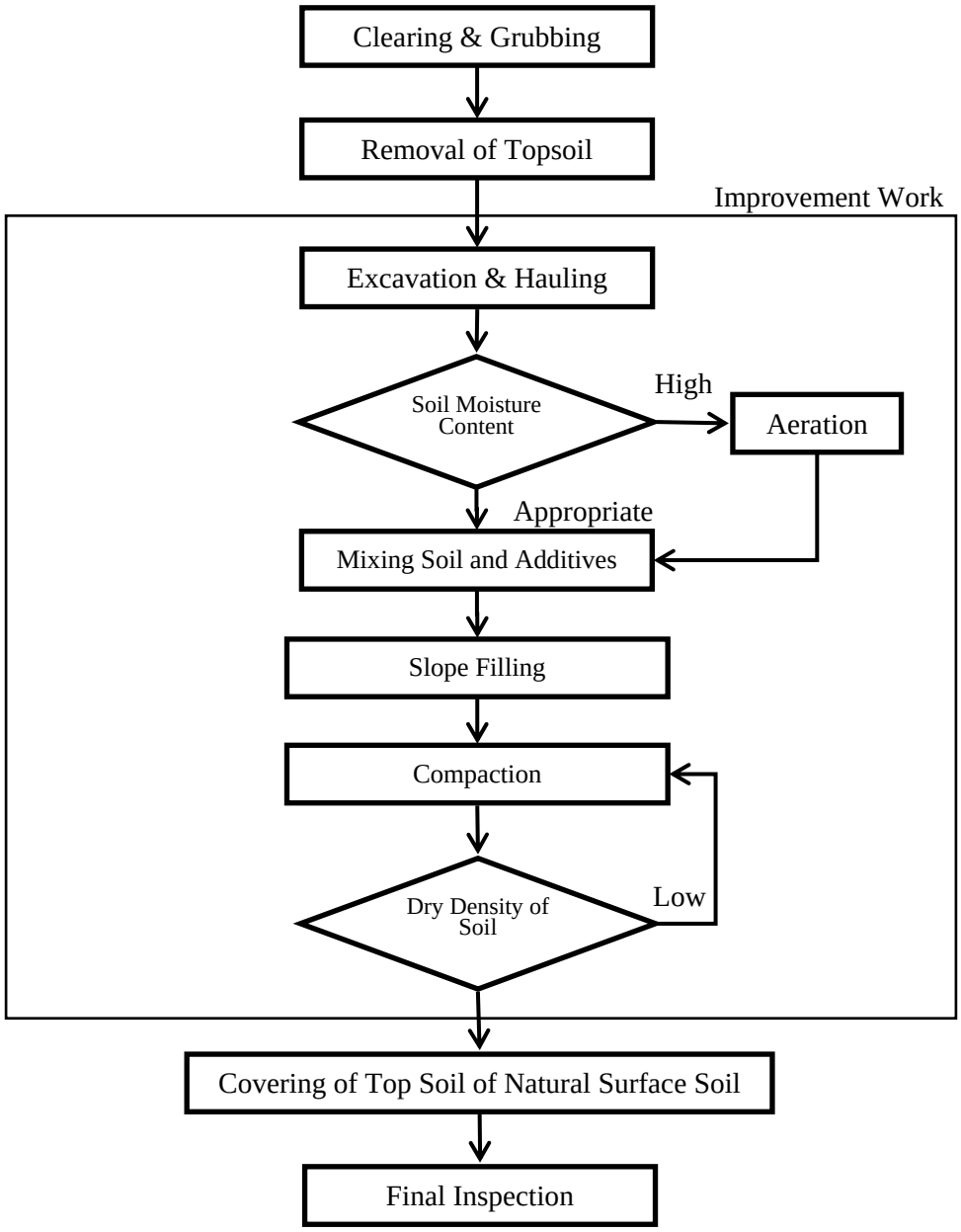


Figure 3.3-2 Pilot Work Procedure

3.3.3 Work Activities

Work activities are shown in Figure 3.3-3. Photographs of work progress are attached in the Appendix 3-3 Photograph of Work Progress.

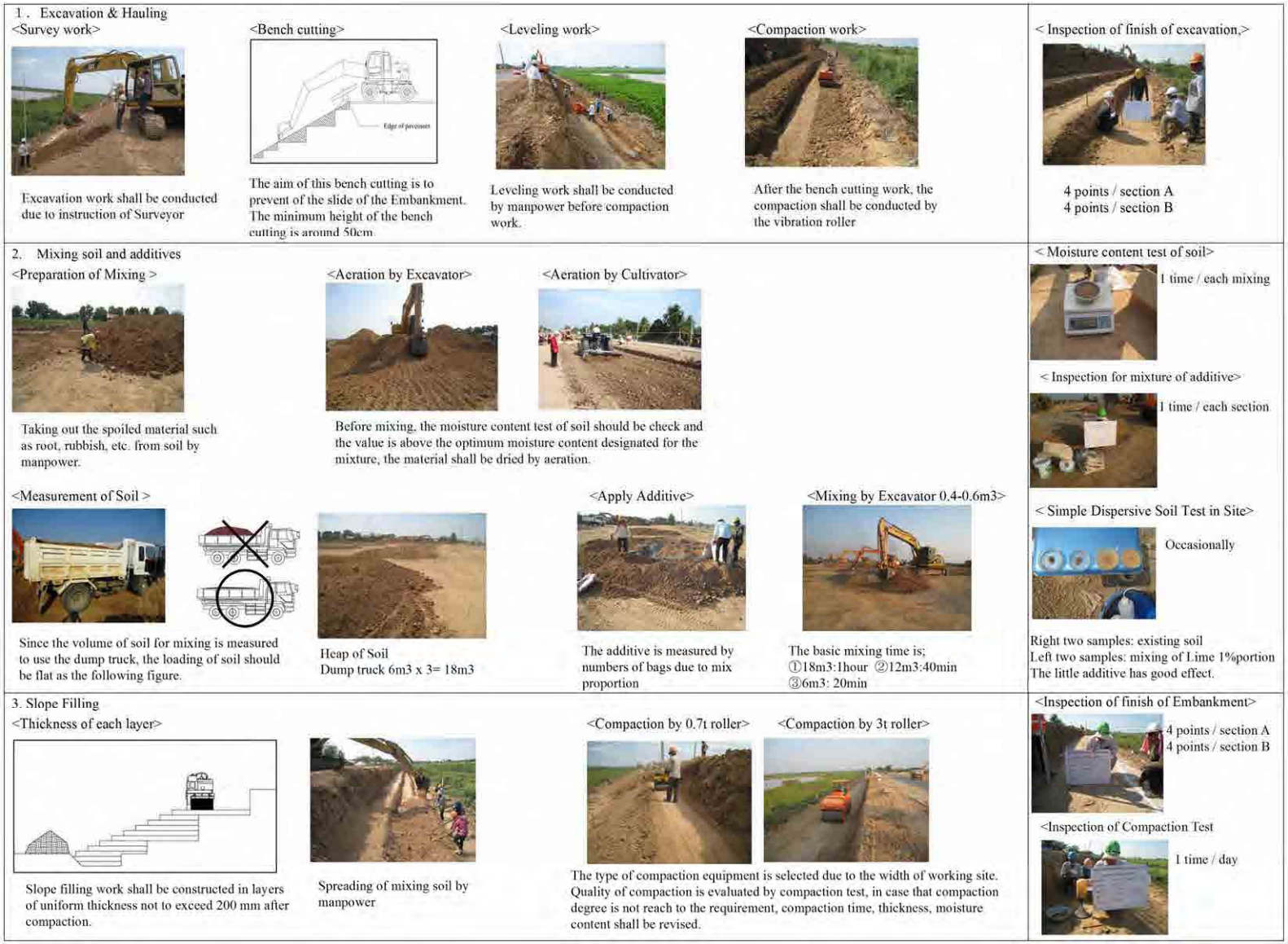


Figure 3.3-3 Pilot Work Activities

3.4 Evaluation of Pilot Work

3.4.1 Site Observation

Site observation was conducted at the middle of August 2012. Since the completion of the pilot work on March 10, 2012, the pilot project site has been exposed in a rainy season for around 3 months. Grass on the road slope has grown up. Gully erosion at the topsoil (which was not improved by adding additives) and a few dragon holes were observed. Photographs of typical damage at the site is shown in Photo 3.4-1. All the photographs of damages are attached in the Appendix 3-4 Photograph of Site Observation.

Distant View of Work Site after Grass Cutting

Gully Erosion by Running Water on the Surface of the Slope

Dragon Hole on the Slope Improved

Dragon Hole on the slope No-improved

Photo 3.4-1 Site Condition after 5 Months from Completion

3.4.2 Actual Performance of Pilot Work

Table 3.4-1 shows the actual performance of the pilot work including work conditions such as kind of additive, mixing rate of additive, soil mixing time, curing period of mixed soil and thickness of improved soil, cost of additive and the observed damages.

Table 3.4-1 Slope Damage and Improvement Conditions (Sec.1 – 8)

Items \ Section No.		1	2	3	4	5	6	7	8
Evaluation of Dispersion in Laboratory Test for Natural Soil (0: Nil, 1: Slight, 2: Moderate, 3: Severe)									
Sample 1 (Top)		3	3	3	2	1	3	3	3
Sample 2 (Middle)		2	1	3	1	3	3	3	3
Sample 3 (Bottom)		0	0	1	3	1	2	3	3
Work Conditions									
Kind of Additive	C: Cement L: Lime	C	C	C	C	C	C	C	C
Mixing Rate of Additive	%	1.0%	1.5%	2.0%	2.5%	3.0%	3.5%	4.0%	4.5%
Soil Mixing Time	Min./m^3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Curing Period of Mixed Soil	day	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thickness of Improved Soil	m	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cost of Additive									
Amount of Improved Soil	m^3	38.20	38.20	38.20	38.20	38.20	38.20	38.20	38.20
Used Amount of Additive	t	0.73	0.82	0.98	1.24	1.68	1.95	2.23	3.07
Unit Price of Additive	us$/t	100	100	100	100	100	100	100	100
Cost of Additive	us$	73.00	82.00	98.00	124.00	168.00	195.00	223.00	307.00
	us$/$m^3$	1.91	2.15	2.57	3.25	4.40	5.10	5.84	8.04
Observed Damage of Slope									
Surface Erosion	Number of Gully erosion	2	3	5	4	4	4	3	3
	Max. depth (m)	0.12	0.15	0.10	0.20	0.14	0.12	0.15	0.14
Dragon hole	Number	0	0	0	0	0	0	0	0
Obstacle to the Work that disturbed the work to be done around it	E.P: Electric Pole B.M: Bench Mark								

Note: Attention points are highlighted with yellow color.

Table 3.4-2 Slope Damage and Improvement Conditions (Sec.9 – 16)

Items \ Section No.		9	10	11	12	13	14	15	16
Evaluation of Dispersion in Laboratory Test for Natural Soil (0: Nil, 1: Slight, 2: Moderate, 3: Severe)									
Sample 1 (Top)		3	0	3	3	3	3	3	3
Sample 2 (Middle)		3	3	3	3	3	3	3	1
Sample 3 (Bottom)		3	2	2	1	2	0	1	3
Work Conditions									
Kind of Additive	C: Cement L: Lime	C	C	C	L	L	L	L	L
Mixing Rate of Additive	%	5.0%	5.5%	6.0%	1.0%	1.5%	2.0%	2.5%	3.0%
Soil Mixing Time	Min./m^3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Curing Period of Mixed Soil	day	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Thickness of Improved Soil	m	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0
Cost of Additive									
Amount of Improved Soil	m^3	38.20	38.20	38.20	38.20	53.09	53.09	53.09	53.09
Used Amount of Additive	t	2.45	1.41	2.71	0.55	0.87	1.09	1.21	1.83
Unit Price of Additive	us$/t	100	100	100	165	165	165	165	165
Cost of Additive	us$	245.00	141.00	271.00	90.75	143.55	179.85	199.65	301.95
	us$/$m^3$	6.41	3.69	7.09	2.38	2.70	3.39	3.76	5.69
Observed Damage of Slope									
Surface Erosion	Number of Gully erosion	5	5	4	4	3	4	4	3
	Max. depth (m)	0.14	0.25	0.16	0.16	0.13	0.14	0.18	0.16
Dragon hole	Number	0	10	0	0	1	3	2	0
Obstacle to the Work that disturbed the work to be done around it	E.P: Electric Pole B.M: Bench Mark		E.P					B.M	

Note: Attention points are highlighted with yellow color.

Table 3.4-3 Slope Damage and Improvement Conditions (Sec.17 – 24)

Items \ Section No.		17	18	19	20	21	22	23	24
Evaluation of Dispersion in Laboratory Test for Natural Soil (0: Nil, 1: Slight, 2: Moderate, 3: Severe)									
Sample 1 (Top)		3	3	3	3	0	3	3	3
Sample 2 (Middle)		3	3	3	3	3	3	3	3
Sample 3 (Bottom)		1	2	1	1	0	1	1	1
Work Conditions									
Kind of Additive	C: Cement L: Lime	L	L	C	C	C	C	C	C
Mixing Rate of Additive	%	3.5%	4.0%	1.0%	1.5%	2.0%	2.5%	1.0%	1.5%
Soil Mixing Time	Min./m^3	3.3	3.3	1.7	1.7	1.7	1.7	1.7	1.7
Curing Period of Mixed Soil	day	0.5	0.5	0.5	0.5	0.5	0.5	3	3
Thickness of Improved Soil	m	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Cost of Additive									
Amount of Improved Soil	m^3	53.09	53.09	53.09	53.09	53.09	53.09	53.09	53.09
Used Amount of Additive	t	2.13	2.42	0.61	0.72	1.22	1.52	0.65	1.29
Unit Price of Additive	us$/t	165	165	100	100	100	100	100	100
Cost of Additive	us$	351.45	399.30	61.00	72.00	122.00	152.00	65.00	129.00
	us$/$m^3$	6.62	7.52	1.15	1.36	2.30	2.86	1.22	2.43
Observed Damage of Slope									
Surface Erosion	Number of Gully erosion	3	6	6	5	3	5	5	3
	Max. depth (m)	0.15	0.12	0.14	0.20	0.28	0.23	0.26	0.30
Dragon hole	Number	0	0	1	1	0	0	1	1
Obstacle to the Work that disturbed the work to be done around it	E.P: Electric Pole B.M: Bench Mark				E.P				

Note: Attention points are highlighted with yellow color.

3.4.3 Findings

As shown in Table 3.4-1 to 3.4-3, some damages were observed but their causes were explained as follows.

Gully erosions which were around 10 to 30 cm in depth on the surface of the slope were observed at the whole slope. This damage occurred because the soil at the surface of the slope was topsoil of 10 cm of design thickness and was not fill of mixed soil with additive but fill of natural soil. This erosion on the surface is not considered to affect the stability of the slope.

There were 20 dragon holes observed in whole site. 12 of 20 dragon holes appeared because the dragon holes were located at special areas where soil of the slope was not improved but remained as they were. The reason why soil there was not improved is that electric pole or bench mark there must be kept stable without disturbing soil around it by the work.

4 of 20 dragon holes were observed at the sections where mixing time was 1.7 min /m^3 and mixing rate was 2.0 % or under.

4 of 20 dragon holes were observed at the sections where mixing time was 3.3 min /m^3 and mixing rate was 2.0 % or under.

As other findings;

There was not any difference in effect of additive between cement and lime. So, cement is recommended as additive for dispersive soil because price of cement is 60 % of lime in Cambodia.

And clear difference of the effect of improved soil thickness between 50 cm and 100 cm in lateral thickness was not found.

General overview:

Improving dispersive soil by cement or lime is;

- 100 % effective when its mixing rate is 2.5 % or more and mixing time is 3.3 min / m^3 or more,
- 95 % effective when its mixing rate is 2.0 % or more and mixing time is 1.7 min / m^3 or more and
- 88 % effective when its mixing rate is 1.0 % or more and mixing time is 3.3 min / m^3 or more.

This suggests that mixing rate is dominant over mixing time for improving dispersive soil.

3.4.4 Necessity of Further Study

3.4.4.1 Further Observation

5 months has passed since the pilot work was completed. There was rainy season of only about 3 months during this term at the site. The project team could see only the indication of the slope deformation from the short period for observation. Therefore, long term observation at least for a year is recommended to evaluate the work with more knowledge.

3.4.4.2 Examination on Introduce of Equipment for Mixing Soil

Backhoe was used to mix soil with additives in the pilot work from the view of easy procurement of machinery. However, it seemed not efficient because it took much time for backhoe to mix soil. More efficient and effective way of mixing soil, like mixing plant, is expected to be introduced. It should be examined in cost of cement or lime, and cost of machinery and its efficiency.

3.5 Recommendation of Use of Dispersive Soil

As mentioned in the Section 3.4.4, further study is necessary to establish more certain way of using dispersive soil for road embankment.

However, it may be said that dispersive soil can be used for construction of road embankment under the conditions mentioned below which are obtained from this study.

- To conduct the simple dispersive soil test in laboratory before construction
- To examine the cost effective way of construction in terms of hauling cost of non-dispersive soil, cost of cement, cost of mixing soil with cement using equipment
- To keep the quality of mixed soil with cement during construction

Work conditions for the effective way of improving dispersive soil are shown below.

Additive: Cement
Cement mixing rate: 2.5 % or more
Mixing machine: Backhoe 0.4-0.6 m^3
Mixing time: 3.3 min / m^3 (60 min / 18 m^3)

CHAPTER 4 TASK 1-3 STUDY OF ROAD INVENTORY

4.1 Background and Necessity of Road Data Information

Currently, Ministry of Public Works and Transport (MPWT) is working not only constructing new road but also mainly making all efforts to maintain the existing road network in an efficient, safe and passable condition. Meanwhile, maintenance works on the national road are managed by Road Infrastructure Department (RID) and management of new constructions is responsible to Heavy Equipment Center (HEC) in accordance with role and responsibility in the sub-decree of MPWT. Those roles and responsibilities are noted only for force account projects. However, department of responsibility for road administration in Cambodia is unknown so that there are many departments or project offices such as RID, HEC, Public Works Research Center (PWRC) and Project Management Unit (PMU) of donor projects to involve the data management of road and bridge with their own responsibility or interest. It is therefore very difficult for MPWT to unify a whole picture of present road network.

In this situation, RID is trying to grasp the latest information of improvement for national roads and of conditions on roads and bridges through Department of Public Works and Transport (DPWT), RID staffs data collection and visual regular inspection.

On the other hand, MPWT will be applying Road Management and Decision Support System (RMDS) to plan any new construction or maintenance work and to know the existing physical and condition characteristics. The RMDS through the Location Referencing and Condition Survey (LRCS) contract was developed in 2004 by financial support from the World Bank (WB). And the RMDS is to become instrument in providing current inventory and condition characteristics to the Road Assets Management Project (RAMP) funded by WB, ADB and other stakeholders and assist in determining road maintenance budgets at present.

There are two ways to prepare the organized information system. It is not systematic under MPWT to manage the road network in Cambodia as national assets. But it is better way to organize and understand the current status of road conditions.

However, those data collection and analysis will be applied to plan repair and rehabilitation program in future work. It means those data are not related to original data, such as when project was completed and by whom original development was supported in the past.

Thus, the project team has pointed out where original and subsequent road data is kept and how road information has to be managed. This Chapter describes the information flow of data collection and output of history sheet for road development through utilization of developed database system in MPWT.

4.2 Current Practice

(1) Road Condition Survey by RID

RID is conducting the regular inspection once in half a year on 1-digit and 2-digit national roads. The regular inspection is to find the defects that shall be repaired as soon as possible, in order to keep national roads in good condition of smooth traffic flow and traffic safety. This regular inspection is being implemented by following the Guideline for Regular Inspection prepared by RID in 2008 with technical assistance from JICA.

[Method of Evaluation]

The inspection does not require any use of complicated method using equipment. This inspection is conducted based on visual rating and estimation of the defects such as patrolling on vehicle inspection and on foot inspection.

[Defect Classification]

Priority ranking is defined in accordance with each type of defect with the degree of severity damage to road pavement at the time of inspection. Therefore, maintenance works are being carried out accordingly based on the ranking result from inspection report.

Table 4.2-1 Defect Ranking

Rank (A)	Severe defects that might be harmful to traffic and it requires urgent countermeasures.
Rank (B)	Defects that might be harmful to traffic and it requires countermeasures but not urgent.
Rank (C)	Small defects that does not require countermeasures but it requires observation.

[Identification of Defect]

During inspection, there are varieties of deterioration to road pavement with the degree of severity. For this reason, prior to inspection, the type of defect ranking from pothole to scratch has predefined with its degree of severity. The defect identification to the road facilities like road marking, guard rail and others is also included in the type of defect.

Table 4.2-2 Condition for Judgment

Defect	Rank	Condition
Pothole	A	
Crack	A	Alligator cracks
	A	Liner crack which is visible from running car
	B	Liner crack which is not visible from running car
Rutting	B	Depth is more than 30mm
	C	Depth is 10-30mm
Deformation Settlement	A	Depth or height is more than 40mm
	B	Depth or height is 20-40mm
	C	Depth or height is less than 20mm
Local Aggregate Loss	A	
Edge break	A	Edge break encroaching on carriage way
	B	Other
Scratch	A	Scratch on DBST
	C	Scratch on Asphalt (AC) or Macadam
Bleeding	B	
Expansion Joint	A	Strong impact or abnormal sound are observed when pass on it/some portions are broken
	B	Impact are observed when pass on it/some portions are deformed
Drainage	A	Cannot drain away or choked
	B	Hard to drain
Marking	A	Hardly see or difficult to see because or fading or covering by soil, litter
	B	Not easy to see
Guard/Handrail	A	Seriously damage, no function, A member interferes traffic
	B	The effect or function are deteriorated
	C	Slightly damage
Signboard	A	Blow out, broken or no function
	B	Damage
Visibility	A	Hardly see or difficult to see
	B	Not easy to see
Obstacle	A	IT interferes traffic
Illegal Occupation	A	Right of Way are occupied illegally by improvable structures

[Output of Record]

Inspectors have to submit the following documents to RID within a week after finishing regular inspection.

RID summarizes the reports using the following sheets from inspectors and prepares the summary to MPWT committee for road maintenance.

- Record sheet for road surface
- Record sheet for road structure, road facilities and others
- Detail sheet in case inspectors regard it as necessary

(2) Road Condition Survey by RAMP

RAMP is carrying out LRCS using RMDS to be supported from WB and other developing partners. Data collection in particular general data of the road assets such as road and bridge is carried out by HEC as a component of RAMP.

The objective of the LRCS is to collect road referencing, inventory and condition data for populating a centralized geographic database which can be used to support sustainable road management planning.

[System of RMDS]

RMDS system consists of various applications such as:

- ROMDAS (Road Measurement Data Acquisition System)
- HIMS (HDM-4 Information Management System)
- HDM-4 (Highway Development Management 4)
- ArcGIS (Geographic Information System)

It means RMDS is instrument in providing current inventory and condition characteristics.

(a) Data Collection and Management

- Condition data is collected with ROMDAS, processed by HIMS before reaching the database.
- HIMS is used to edit and update network and road attribute data.
- ArcGIS is used to maintain the spatial data in the geographic database directly and via HIMS.

(b) Analysis and Enquiry

- Data is exported by HIMS to a format that can be used by HDM-4/RED (Road Economic Decision Model).
- HIMS can be used to complete data queries such as finding all sealed roads with IRI > 6.
- ArcGIS can be used spatial analysis.

(c) Reporting and Mapping

- Road Map provides an intuitive interface to a subset of the database exported from HIMS.
- HIMS can be used to extract basic reports on condition, lengths, location and inventory.
- ArcGIS can be used to produce thematic maps of road condition.

[Content of LRCS]

LRCS survey's primary purpose is to establish a common linear referencing system and geographic map, which will allow activities along the road network to be assigned a unique address.

LRCS is the collection of road inventory and condition data including; pavement surfacing, international roughness index (IRI), surface integrity index (SII) and drainage. LRCS survey is completed from a moving vehicle and as such captures inventory and visual condition data at a lesser accuracy (quality level) than if staffs were to take direct measurements. Thus, the survey is able to provide a large quantity of data in a timely and cost effective manner. This approach provides MPWT with sufficient base information to implement decision planning tools such as HDM-4.

[Output of Record]

Six road inventory attributes are observed and recorded from the moving vehicle. These are shown in Figure 4.2-1 below.

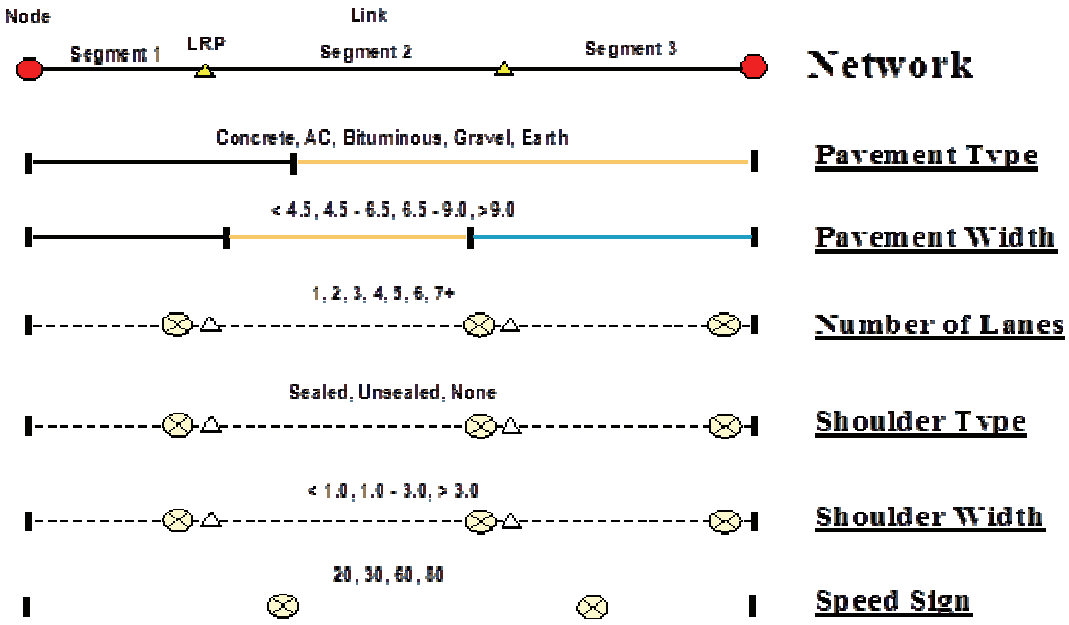


Figure 4.2-1 Road Inventory Attribute

Pavement Type and Width were recorded as continuous events (whenever there was a change) while the "typical" number of lanes, shoulder type and width were recorded at the end of each segment and assumed to be uniform for that segment. Speed signs were recorded wherever seen and entered as a point event.

And six road condition attributes were also observed and recorded from the moving vehicle. These are shown in Figure 4.2-2 below.

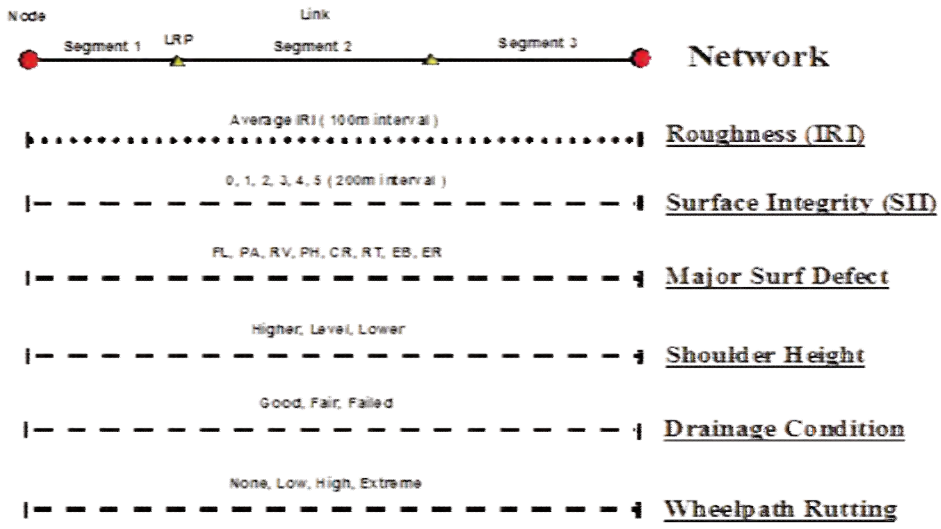


Figure 4.2-2 Road Condition Attribute

IRI was recorded automatically every 100m while the SII, major defect type, shoulder height, drainage condition and rut level were recorded at the end of each 200m section and assumed to be uniform for that section. During the post processing adjacent sections with the same rating were combined.

The following outputs have been obtained from LRCS as well.

- Traffic Survey
- Bridge and Culvert Inventory
- Creation of GIS Mapping

4.3 Proposal of Road Data Information System

The project team surveyed and observed inventory system in the previous section. On the other hand, the project team established the database management system and has been collecting the completion documents to keep into database. Unfortunately, this database system was not linked to the current inventory system as mentioned above.

During this Project, the project team also established the Regulation (RG) for force account projects. RG clearly requires to submit "Project Information" sheet (Table 4.3-1) to Party A (MPWT, General Directorate of Public Works) when project is complete under force account. Meanwhile, the project team recommended that donor projects also have to submit the completion documents to counterpart ministry in the same manner. With the recommendation, MPWT is going to issue instruction letter to all PMUs for donor projects in charge regarding formulation of submission rule for completion documents including "Project Information". The project team suggested to MPWT this "Project Information" sheet is necessary and important documents for future data information so that all of Party B and PMU shall prepare it and PWRC shall input it into database system in MPWT.

After data information was inputted to database system, MPWT shall play and observe the update road information easily. Figure 4.3-1 describes the flow of submission and image of output is shown in Table 4.3-3.

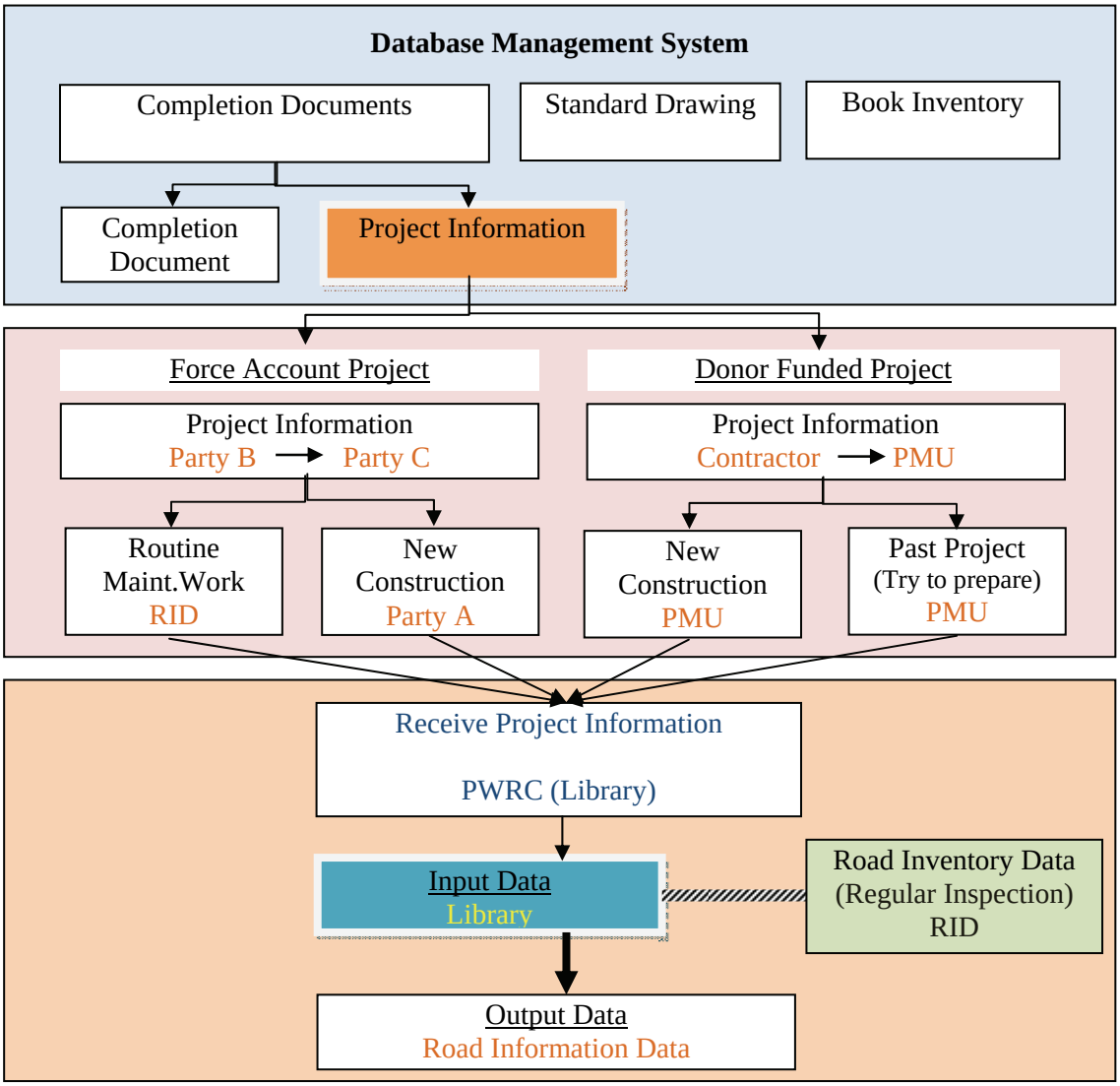


Figure 4.3-1 Data Input for Project Information

Table 4.3-1 Project Information (Sample)

(1) Basic Data		
1-1	Project name	*Rehabilitation of National Road 71*
1-2	Project fund	*National Budget Chapter 61*
1-3	Location & Road number	*Kampong Cham Province* *National Road 71 (PK2+160 ~ PK 10+940)*
1-4	Employer / Party A	*General Director of Public Works*
1-5	Executor / Party B	*DPWT Kampong Cham*
1-6	Supervisor / Party C	*Road Infrastructure Department (RID)*
1-7	Inspector / Party D	*Procurement Evaluation Award Committee (PEAC)*
1-8	Designer	*DPWT Kampong Cham checked by RID*
1-9	Others	

(2) Technical Data		
2-1	Road Length & Beginning and End Points	*2.5 km,* *Section I : 680 m (PK 2+160 - PK 2+840)* *Section II: 1,380 m (PK 4+210 – PK 5+590)* *Section III: 440 m (PK 10+500 – PK 10+940)*
2-2	Road Section	*(1 lane + shoulder) x 2 ways* *as 1 m (shoulder) – 3.5 m (1 lane) – 3.5 m (1 lane) – 1 m (shoulder)*
2-3	Earthwork	*Reconstruction of existing SBST road*
2-4	Pavement	*Capping layer (30 cm) – Sub Base (20 cm) – Base Course (20 cm) – DBST*
2-5	Others	

(3) Contract Data		
3-1	Contract Amount: Original Final	*Riel 1,650,000,000.00* *Riel 1,729,000,000.00*
3-2	Schedule	*October 21, 2011 – April 25, 2012*
3-3	Completion Date (PEAC)	*May 18, 2012*
3-4	Inspection after Warranty Period	*(Plan) May 18, 2013*
3-5	Others	

Output of data highlights the index which has searchable database. Users may find the target road through following index.

Table 4.3-2 Proposed Index

Classification	ID	Code	Index Items
Road Number	01	1	National Road No.1
	02	21	National Road No.21
Bridge Number	01	1	A bridge (National Road No.1)
	02	21	B bridge (National Road No.21)
Province	01		Banteay Meanchey
	02		Battambang
Fund Source	01	GVT	Force Account (Chapter 61)
	02	ADB	Asian Development Bank
	03	JPN	Japan
Year	01	90	Year 1990 - 1995
	02	06	Year 2006 - 2010

When library is sorting out project information, data in the past and current projects will be effectively utilized and then productivity in searching data is much improved. Output data must be easy for users to understand the situation of road network and conditions. The following Table 4.3-3 describes image of output data.

Table 4.3-3 Image of Output

Road No.	**Road Classification**			**Location**									
Province													
Width (m)	Formation		Pavement			PK	+		PK	+	Length (m)		
Surface Type					Start			End					
History	Fund Source				Contractor (Party B) & Consultant (Party C)						Year	Cost	
Original Construction													
Routine Maintenance													
Rehabilitation													
Road Function													
Traffic	Total Vehicles / Day			Growth Rate % / year			Commercial Veh. / day						
Current Conditions													
Defect Description													
Factors													
Surface Rating (SII)		Description											
Roughness (IRI)													
Pvt Strength (FWD)													
Major Issues (Soi Condition etc.)													
Proposed Maintenance													
Default Program	Resurfacing	Proposed Program / Component	Resurfacing										
			DBST										
Surfacing		**Capping Layer**			**Pavement Sub-Base**				**Base-Course**				
Type		Type			Type				Type				
Width (m)		Width (m)			Width (m)				Width (m)				
AC (mm)		Depth (mm)			Depth (mm)				Depth (mm)				

4.4 Recommendation

(1) Submission of Project Information

Although both force account and donor funded projects were completed in adequate manner, data information is necessary and important for MPWT to keep the real time data management. Project Information sheet is a help of data collection to grasp the Cambodian road network. Road management in charge shall strongly instruct Party B / Party C and PMU to submit data, including routine maintenance works time to time.

In addition, the past projects are also required to prepare Project Information sheet as much as possible.

(2) Fruitful Output Data Sheet

In order to obtain and sustain the road data information system, road management in charge shall develop fruitful output sheet. This output sheet shall be transmitted to users, including high ranking people in MPWT so that road management in charge shall consider how to update and prepare in a comprehensive form.

(3) Integration of RAMP Data

RAMP is implementing the establishment of database management relating to current road condition under their component. MPWT shall apply both established database system and RAMP database to obtain all of data for road network in Cambodia.