## 4.3 CIVIL ENGINEERING FACILITIES

The descriptions in this section are based on the information obtained from visits to each Zonal Railway and site surveys carried out during the first stage of this project in July 2006. These site surveys allowed the engineers on the project team to see the actual conditions and take them into consideration along with the information in the RITES Report. This section also describes the current conditions of the existing facilities of Indian Railways based on the supplemental field survey and the RITES PETS-II report and other such information.

### 4.3.1 Standards of Construction

Standards of Construction for Broad Gauge (BG) of Indian Railways are as follows:

The BG lines have been classified into five groups “A” to “E” on the basis of the future maximum permitted speed.

- Group “A”: Speed up to 160 km/hr
- Group “B”: Speed up to 130 km/hr
- Group “C”: Suburban sections of Mumbai, Delhi, Kolkata
- Group “D”: Sections where the sanctioned speed is 100 km/h at present

- Group “E”: Sectional and branch line with the traffic density is very high or likely to grow substantially in future and the sanctioned speed is less than 100 km/h

Along DFC route, Eastern Corridor (Delhi - Kanpur - Allahabad - Mughal Sarai - Gaya - Howrah) and Western Corridor (Delhi - Mathura - Ratlam - Vadodara - Mumbai) are classified as Group A, and Eastern Corridor (Ludhiana – Ambala - Delhi) is classified as Group B.

**Table 4-5 Standards of Construction of IR**

| | |
|---|---|
| Gauge | 1676mm |
| Max. Permissive Speed | Group A : 160 km/hr, Group B : 130 km/hr |
| Max. Gradient | In plane country : 1 in 150, In hilly terrain : 1 in 100 |
| Max. degree of curves | 10 degree (R=175 m) |
| Max. Cant | 165 mm |
| Max. Cant Deficiency | 100 mm |
| Max. Cant Excess | 75 mm |
| Type of Transition Curve | Cubic Parabola |
| Min. radius of Vertical Curve | Group A : 4,000 m, Group B : 3,000 m |
| Type of Turnout | 1 in 8.5 or 1 in 12 |
| Axle load | 22.9 ton |
| Type of Track Structure | Ballasted Track or Ballastless Track ( in the station) |
| Rail | 52 kg/m or 60 kg/m |
| Sleeper | Pre-Stressed Concrete (PSC) Sleeper |
| Sleeper Density | Nos.1550 /km or Nos. 1660/km |
| Min. Thickness of Ballast | 250-300 mm or 200 mm over 150 mm sub-ballast (in case of PSC Sleeper) under sleeper |

Reference
(1) *“Indian Railway Permanent Way Manual Second Reprint 2004” (05 Mar 2004)*
(2) *”Indian Railway Track”(M.M. AGARWAL, 2004)*

The establishment or amendment of technical standards for Indian Railways is conducted by the Research Designs and Standards Organisation (RDSO).

This covers all aspects of technical standards of Indian Railways, such as design criteria, construction standards, material specifications, and standard design drawings.

The standards which the JICA Study Team obtained are shown below;

1) Indian Railways Permanent Way Manual
2) Indian Railways Manual of AC Traction Maintenance and Operation
   a) Volume I General, March 1994
   b) Volume II (Part I) Fixed Installations 1994
   c) Volume II (Part II) Fixed Installations (List of Appendices) 1994
3) Indian Railways Signal Engineering Manual
4) Indian Railways Bridge Manual
   a) Bridge Rules (Incorporating A & C Slip No.33, 2005)
   b) Concrete Bridge Code (Incorporating A & C Slip No.7, 2003)
   c) Steel Bridge Code (Incorporating A & C Slip No.17, 2003)
   d) Bridge Sub-structure & Foundation Code
      (Incorporating A & C Slip No.22, 2003)
   e) Welded Bridge Code (Incorporating A & C Slip No.2, 1989)
   f) Well & Pile Foundation Code (Revised Edition-1985)
5) Indian Railway Standard Track Manual
   a) Volume I Chapter I to VI (1994)
   b) Volume II Chapter VII to XII & Annexure to Vol. II (1989)
6) Indian Railways Code for the Engineering Department (Third Reprint 1999)
7) Guidelines for Earthwork in Railway Projects (Guideline No. GE: G-1, July 2003)
8) Indian Railway Schedule of Dimensions BG (2004)
9) Specification for Mechanically Produced Blanketing Material for Railway Formations Including Guidelines for Laying (Specification No. GE: IRS-2, July 2005)

### 4.3.2 Track

#### (1) General

The type of track adopted by the Indian Railways is ballasted track, and in some important stations ballastless tracks are used.

Typical profile of ballast track structure is shown in Figure 4-10 and Figure 4-11.

The Study Team observed the track is being well maintained. Track irregularity and mud pumping were not found on tracks during the site investigation.

The Indian Government established the Special Railway Safety Fund (SRSF) to tighten security of railways and strengthen railway infrastructure. SRSF amounting to Rs.17,000 Cr. were allocated to liquidate arrears of replacement of assets including track. After creation of this fund, track renewal work got a boost. According to Year Book 2004-2005, track renewal of 5,500 km length was carried out in 2004-05.

The track improvement works include replacement of 52 kg/m rail with 60 kg/m rail, replacement of wooden sleepers with PSC (Prestressed concrete) sleepers for lines with high speed and heavy axle load operation.

### (2) Rail

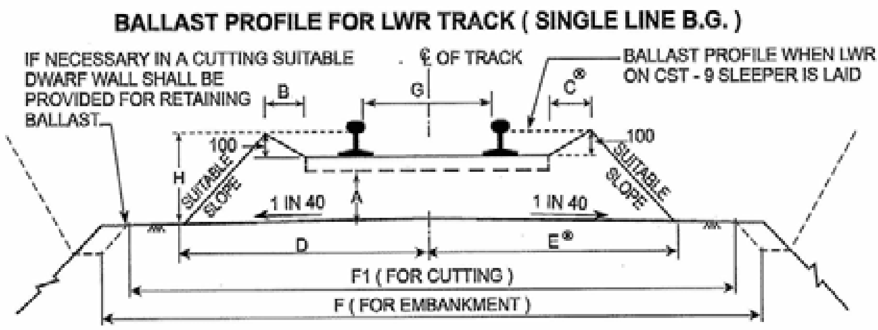
52 kg/m or 60 kg/m 90 kgf/mm$^2$ UTS rail are mainly used in main lines.

Standard 13 m rail are welded into LWR (Long welded rail) to reduce track maintenance cost and improve riding quality

According to *Year Book 2004-2005* approximately 77% of the total length is covered by LWR and approximately 72% are installed with 52 or 60 kg rails on BG track.

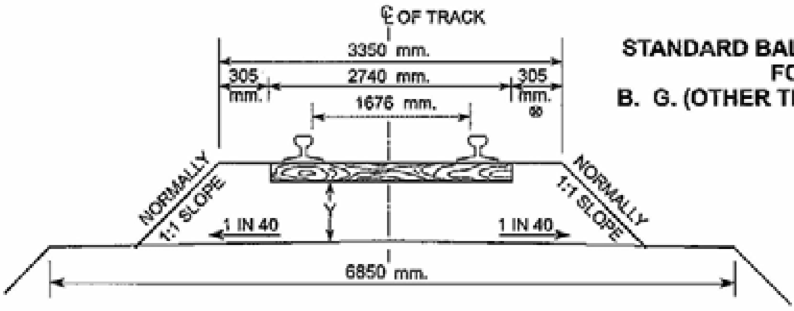
52 kg/m rail is being replaced with 60 kg/m rail to accommodate operation of 25 tonne-axle load trains on main lines and feeder lines.

60 kg/m rail are used on new lines and double tracking project.




| G Gauge | Type of Sleeper | A | B | C* | D | E* | F | F1 | H | Quantity of Ballast per meter in Straight Track | Quantity of Ballast per meter in Curved Track | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1676 mm | Wooden | 250 | 350 | 500 | 2,270 | 2,420 | 6,850 | 6,250 | 540 | 1.682 M³ | 1.646 M³ | 1. The Minimum Clean Stone Ballast cushion below the bottom of sleeper i. e., A–250 mm.<br>2. For routes where increase in speeds are to be more than 130 Km.p.h. A–300 mm. or 200 mm. along with 150 mm. of sub-ballast.<br>3. Suitable dwarf walls shall be provided in case of cuttings, if necessary for retaining ballast.<br>4. *On outer side of curves only.<br>5. Cess may be widened where required depending on local conditions and outside of curves.<br>6. All dimensions are in mm.<br>7. ¶ 200 over 150 Sub-Ballast. |
| | " | 300 | " | " | " | " | " | " | 590 | 1.782 " | 1.853 " | |
| | " | ¶ | " | " | " | " | " | " | 640 | 1.982 " | 2.060 " | |
| | Steel Trough | { 300 | 350 | 500 | 2,280 | 2,430 | 6,850 | 6,250 | 550 | 1.762 M³ | 1.827 M³ | |
| | | ¶ | " | " | " | " | " | " | 600 | 1.962 " | 2.035 " | |
| | | | " | " | " | " | " | " | 650 | 2.162 " | 2.242 " | |
| | PRC | 250 | 350 | 500 | 2,360 | 2,510 | 6,850 | 6,250 | 630 | 1.954 M³ | 2.032 M³ | |
| | " | 300 | " | " | " | " | " | " | 680 | 2.158 " | 2.243 " | |
| | " | ¶ | " | " | " | " | " | " | 730 | 2.362 " | 2.455 " | |
| | 2 Block | 250 | 350 | 500 | 2,360 | 2,510 | 6,850 | 6,250 | 630 | 2.110 M³ | 2.193 M³ | |
| | " | 300 | " | " | " | " | " | " | 680 | 2.314 " | 2.405 " | |
| | " | ¶ | " | " | " | " | " | " | 730 | 2.518 " | 2.616 " | |

**Figure 4-10 Ballast Profile for LWR Track (Single Line B.G)**




**STANDARD BALLAST PROFILE FOR B. G. (OTHER THAN LWR/ CWR)**

| RECOMMENDED DEPTHS OF BALLAST AND BALLAST REQUIREMENTS FISH-PLATED TRACK | | | |
|---|---|---|---|
| Group | Recommended Depth of Ballast Cushion Y | Quantity of Ballast Required/Metre | |
| | | On Straight and Curves of Radius Flatter than 600 M | Curves of Radius Sharper than 600 M |
| A | 300 mm. | 1.568 $M^3$ | 1.634 $M^3$ |
| B & C | 250 mm. | 1.375 $M^3$ | 1.416 $M^3$ |
| D | 200 mm | 1.167 $M^3$ | 1.202 $M^3$ |
| E | 150 mm. | 0.964 $M^3$ | 0.996 $M^3$ |

**Note :**

(1) In the case of ordinary fish-plated track : * To be increased on the outside of curves to 400 mm. in the case of curves sharper than 600 M. radius.

(2) In short welded panel Track * To be increased to 400 mm. on outside of all curves, flatter than 875m radius and to 450mm. In the case of curves sharper than 875m. radius.

(3) *To be increased to 550 mm. on the outside of turn in curves of turn-outs in passenger yards.

(4) In the case of S. W. R. track, the minimum depth of cushion shall be 200 mm.

**Figure 4-11 Standard Ballast Profile for B.G. (Other than LWR/CWR)**

### (3) Fastening

Fastening utilised on main tracks are elastic-fastening type (Pandrol). The introduction of this type of fastening enables the Indian Railways to operate at high speed or high axle load, and effective in reducing maintenance cost.

### (4) Sleeper

The type of sleepers utilised on main lines are PSC sleeper except for bridge section. Although wooden, steel, and cast iron sleepers have been used in the past, they are being replaced by PSC sleeper in the recent track renewal.

Sleeper installation density is currently at 1,550 or 1,660 units per km. For rail replacement works sleepers are placed at 1,660 units per km.

On bridge section wooden or steel sleepers are used.

### (5) Ballast

The depth of ballast is 250 to 300 mm under sleeper.

As is indicated on the track diagram, in considerable sections hardened lower layer of ballast what is called "cake" has accumulated to a thickness of 100 to 200 mm over the years due to crushing of ballast by passage of trains. This is to be removed through ballast cleaning.

### (6) Turnout

The type of turnout utilised on the Indian Railways vary from 1 in 8.5, 1 in 12, 1 in 16, and 1 in 20.

The permissible speed of curved switch is 15 km/h on 1 in 8.5 turnout and 30 km/h on 1 in 12 turnouts.

Most of the crossing are fixed crossing and is made of cast manganese steel (CMS).

The sleeper of turnout is PSC sleeper which can used either for right or left turnout.

### (7) Maintenance

All maintenance activities of the tracks are carried out complying with "*Indian Railway Permanent Way Manual*". The contents of this manual are considered to be of high standard and it is written in English and Hindu for use throughout the country.

The inspections, for example, observation by inspector, track recording car, are recorded on computers.

"*Track Diagram*" specifies the track material (rail, fastening, ballast thickness etc) and maintenance period are stipulated.

Re-alignment of track, tamping, ballast cleaning, are mechanised.

Reference
(1) "INDIAN RAILWAY PERMANENT WAY MANUAL Second Reprint 2004" (05 Mar 2004)
(2) INDIAN RAILWAY TRACK ( M.M. AGARWAL, 2004)
(3) Hearing from Zonal Railway, RITES and RDSO

## 4.3.3 Earth Work

Most of the existing lines are running on earthwork embankment sections. Depending on the geographical feature, there are some sections with high embankments that rise 10 m above the surrounding ground level. Viaduct sections were not noticed, probably because most of the sections were constructed in 19$^{th}$ century since land at that time was easily available for embankment width.

It was reported that the spacing of the tracks was 5.30 m during interaction with one of the Zonal Railways. However, the observation made by the JICA Study Team concluded that most of the spacing of the tracks was about 4.0 m. Also as indicated in the figure on the construction gauge in the JICA Preliminary Survey Report, the spacing of most of the existing tracks is 4,265 mm (14 feet) as per the original design. This aspect is also mentioned in 'Indian Railways Schedule of Dimensions 1676mm Gauge (revised 2004)' that the 5.30 m spacing of tracks is for new works/additions to existing works. Therefore, the 5.3m spacing which is shown in the formation width for banks and cuttings, was adopted for a few sections.

The current condition of the sections between Allahabad and Mughal Sarai on the Eastern corridor was observed by the JICA Study Team from the driver's cabin. The JICA Study Team confirms that this section is located in the flat terrain and its alignment is good and well maintained as was reported in JICA Preliminary Survey Report.

The current condition of the section between Ahmedabad and Vadodara on the Western corridor was also observed from driver's cabin and found to be in good condition. One common factor in these sections is that both had the geographical feature of being mostly flat and that the ground levels on both side of the track were lower than that of the surrounding ground. From this it can be assumed that the railway embankment was made with soil/material excavated from either one side or both sides.

However, since the material for the track embankment has been used from the overburden at the time of construction, it is highly probable that it is not suitable for track bed, particularly from a soil engineering viewpoint. This concurs with information provided by some officers of Zonal Railways about the difficulties of track maintenance, because of frequent ground settlement.

The ground settlement issue suggests another possibility, that improvement for soft ground was insufficient when the embankment work was carried out. Since the existing line, especially the main line, has been in use for more than 100 years and the ground should have been settled, the cause of track settlement could be washout of materials of either track bed or track embankment. For the construction of the DFC, the planned embankment section along the above mentioned existing lines has the risk of damage in the existing line by circular slip or ground movement, when the earth work for DFC is carried out. Therefore, a thorough investigation and countermeasures at the detailed-design stage will certainly be required.

According to the information acquired through discussion with RITES, only approximately 100 km long section between Mumbai and Surat of the Western Corridor may have problems relating to soft ground conditions.

### 4.3.4 Bridges and Culverts

#### (1) Current Situation of Bridge Construction in India

Bridges and box-culverts are used to cross rivers, railways, roads, and canals on the existing lines. Except for the bridges spanning across large rivers, nearly all of these structures are constructed either using deck plate girder or of concrete box culvert type.

According to Zonal Railways Officials, these bridges are classified as follows;

Important Bridges: Bridge having a linear waterway of 300 meters or a total waterway area of 1,000 $m^2$ or more is classified as important bridges by the Chief Engineer/Chief Bridge Engineer. Classifications may also depend on considerations of depth of waterway, extent of river training works and maintenance problems.

Major Bridge: Bridges that have, either a total linear waterway of 18.3 meters (60ft) or more or they have a clear opening of 12.2 meters (40 ft) or more in any one span.

Minor Bridge: Bridges that do not fall into the above categories.

Most of the Important Bridges are steel truss structures built during the British colonial era of the $19^{th}$ century. Some of these bridges are used for both rail and road traffic. It appears that there are mainly two span-arrangement patterns, 61 meters (200 feet) and 30.5 meters (100 ft). The old bridges receive extremely good operational maintenance. Even the maintenance records for each section of the bridge are recorded on the girders. Unfortunately, despite the excellent maintenance of the bridges, the wooden sleepers are relatively in poor condition. While there was mention of plans to replace these wooden sleepers with steel structures, it appears that the timing of this replacement work has been delayed.

A new bridge is being built along the existing line at the northern region between Ambala and Ludhiana. The design of the bridge is a 100 ft spans steel truss bridge that is identical to the type as the existing bridges which were built ages ago. In the meetings with the Zonal

Railway Official's it was mentioned that in recent years there was a policy to use steel truss construction for new bridges having a span of 30 meters or more, and PSC girder for bridges having a span less than 30 meters. On the other hand, the Sone Bridge having similar span, was referred to in the RITES Preliminary Report that new bridges will be of a PSC box girder design. Whether this is a deviation from Zonal Railway policy or if a separate standard has been established is a subject for investigation.

Older major bridges are deck plate girders; those more recently built are either reinforced concrete (RC) or PSC girders. The span-arrangement for both the old and new bridges appears to be nearly the same. It is thought that the reason for replacing the bridges is deterioration and not due to other factors, such as river improvement.

As for the minor bridges, it appears that mainly concrete box-culverts are utilised, with the older ones apparently using short-span deck plate girders.

The bridges, regardless of classification, mainly applied a continuous short-span simple beam construction. It is assumed that this design policy was not applied considering the hindrance ratio of stream flow of a river, but rather the result of the priority given to controlling the cost of railway bridges.

However, while it is unclear whether or not this is the optimum strategy for improving existing bridges, structural planning should be conducted through careful examination of the need and potential for controlling the hindrance ratio of stream flow of a river for the construction of new DFC lines.

Since a standard 10 to 15 m approach slab is provided at the area where the bridge and the earthwork intersects, there is need for concern about unevenness developing in this area.

There is definitely a need for concern about India's construction capacity to implement these structural works. If construction of the some 3,000 km of the DFC were to commence simultaneously, the balance of demand and supply of the construction market would deviate and there would not be sufficient capacity for its execution. It is also quite possible that this could also lead to increase of cost of construction material. Therefore, the Indian Government might be required to develop comprehensive and pre-emptive strategies for addressing such issues. There is also a need to implement engineering countermeasures such as preparing standards for structures on a national scale and creating an appropriate plan for the mass production of formworks and basic materials.

### (2) Current Situation of Bridge Design Process

Bridge design process in India, in principle, is carried out by Research Designs and Standards Organization (RDSO). RDSO prepares the standard drawings according to the standard design, and distributes it to Zonal Railway for their new bridge construction. The Zonal Railways fabricate and erect / construct the bridges according to these standard drawings. The Zonal Railways have their own Bridge workshops for their fabrication. When the capability of the shop is not enough for any bridge, they order the fabrication to a private fabricator. As the result of the shop survey, although Rivets are used for the splicing, the quality of the standard bridge is quite good because of their numerous fabrication experiences, based on the standard design.

Generally, Manuals and Specifications are prepared adequately. The standard drawings are prepared for every Axle Load and Span length. Accordingly, the positive attitude to economization due to standardization will be understood easily.

Codes and Manuals are shown on Table 4-6; Standard drawings are shown on Table 4-7

**Table 4-6 Codes and Manuals for Bridge Design**

| S.No. | Name of Codes/ Manuals | |
|---|---|---|
| 1 | IRS Bridge Rules | Adopted - 1941<br>Revised -1964<br>Reprinted - 2001 |
| 2 | IRS Concrete Bridge Code | Adopted - 1936<br>Revised -1997 |
| 3 | IRS Bridge Substructures and Foundation Code | Adopted - 1936<br>Revised -1985<br>Reprinted - 1991 |
| 4 | IRS Steel Bridge Code | Adopted - 1941<br>Revised -1962<br>Reprinted - 1977 |
| 5 | IRS Welded Bridge Code | Adopted - 1972 |
| 6 | Indian Railway Bridge Manual | Adopted - 1998 |
| 7 | IRS/B1-1979 Specification for Fabrication and Erection of Steel Girders bridges and locomotive turn-tables.(S.No.B1-79) | Adopted - 1934<br>Revised - 1979 |
| 8 | Arch Bridge Code | Adopted - 1941<br>Revised - 1962 |
| 9 | IRS Code of practice for the structural design of Microwave towers of self supporting type (self supporting Microwave tower code) | Adopted - 1974<br>Revised - 1982 |
| 10 | IRS Code of practice for fabrication and erection of steel work of Microwave towers of self-supporting type. | Adopted - 1979 |
| 11 | Manual on the Design and Construction of Well and Pile Foundations. | Adopted - 1985 |

**Table 4-7 Standard Drawings for Bridge Design**

| | | Bridge Type | Gauge | Loading | | Description | Span (m) | Remarks |
|---|---|---|---|---|---|---|---|---|
| Steel Bridge | 1 | Open Web Girder (B.G.) Rivetted Type | B.G(1676mm) | MBG | 1 | RBG | 30.5 | |
| | | | | | 2 | RBG | 45.7 | |
| | | | | | 3 | RBG | 61.0 | |
| | | | | | 4 | BGML | 76.2 | Rivetted |
| | | | | | 5 | RBG | 30.5 | Under slung type |
| | 2 | Open Web Girder (M.G.) | M.G(1000mm) | ML | 1 | MGML | 30.5 | |
| | | | | | 2 | MGML | 45.7 | |
| | | | | | 3 | MGML | 61.0 | |
| | | | | | 4 | MGML | 30.5 | Under slung type |
| | 3 | Open Web Girder (B.G.) Welded Type | B.G(1676mm) | MBG | 1 | MBG | 30.5 | |
| | | | | | 2 | MBG | 45.7 | |
| | | | | | 3 | MBG | 61.0 | |
| | | | | | 4 | MBG | 76.2 | |
| | 4 | Open Web Girder (B.G.) Welded Type | B.G(1676mm) | HM | 1 | HM Loading | 30.5 | |
| | | | | | 2 | HM Loading | 45.7 | |
| | | | | | 3 | HM Loading | 61.0 | |
| | 5 | Open Web Girder (M.G. to B.G.) Gauge Conversion | M.G(1000mm) to B.G(1676mm) | Not mentioned | 1 | Modification to MGML | 30.5 | |
| | | | | | 2 | Modification to MGML | 45.7 | |
| | | | | | 3 | Modification to MGML | 45.7 | |
| | 6 | Plate Girder (B.G.) | B.G(1676mm) | MBG | 1 | MBG-1987 | 12.2 | Welded |
| | | | | | 2 | MBG-1987 | 18.3 | |
| | | | | | 3 | MBG-1987 | 24.4 | |
| | | | | HM | 4 | HM Loading | 12.2 | |
| | | | | | 5 | HM Loading | 24.2 | |
| | 7 | Plate Girder (M.G.) | M.G(1000mm) | ML | 1 | MGML | 6.1 | Welded |
| | | | | | 2 | MGML | 9.2 | |
| | | | | | 3 | MGML | 12.2 | |
| | | | | | 4 | MGML | 18.3 | |
| | | | | | 5 | MGML | 24.4 | |
| | | | | | 6 | MGML | 30.5 | |
| | 8 | Plate Girder (M.G. to B.G.) Gauge Conversion | M.G(1000mm) to B.G(1676mm) | Not mentioned | 1 | Modification to MGML | 9.2 | |
| | | | | | 2 | Modification to MGML | 12.2 | |
| | | | | | 3 | Modification to MGML | 18.3 | |
| | | | | | 4 | Modification to MGML | 24.4 | |
| | 9 | Composite Girder (B.G.) | B.G(1676mm) | MBG | 1 | Modification B.G. Loading 1987 | 12.2 | |
| | | | | | 2 | Composite Bridge | 18.3 | |
| | | | | | 3 | Modification B.G. Loading 1987 | 20.0 | |
| | | | | | 4 | MBG Composite Girder-Welded Type | 9.2 | |
| | | | | | 5 | MBG Composite Girder-Welded Type | 24.4 | |
| | | | | | 6 | MBG Composite Girder-Welded Type | 18.3 | |
| | 10 | Composite Girder (M.G.) | M.G(1000mm) | ML | | MGML | 12.2 | |
| | 11 | Continuous Girder | B.G(1676mm) | MBG | | BGML | 3 x 9.2 | |
| | | | | | | BGML | 3 x 60ft(18.3m) | |
| Prestressed Concrete Bridge | | Prestressed Concrete Girder | B.G(1676mm) | MBG | 1 | MBG Loading-1987 | 12.2, 18.3 | |
| | | | | | 2 | Prestressed Concrete Girder(Post Tension I Type) | 12.2 | |
| | | | | | 3 | Prestressed Concrete Girder(Post Tension I Type) | 18.3 | |
| | | | | | 4 | Precast Post Tensioned PSC Box Girder | 30.5 | |
| | | | | | 5 | Precast PSC (Post Tensioned) Ballastless Box Girder | 29.87 | |
| | | | | | 6 | Precast Post Tensioned PSC Box Girder | 45.1 | |
| | | | | | 7 | Precast Prestressed Concrete 3 T-Girder | 12.2 | |
| | | | | | 8 | Expansion Joint for Railway Concrete Bridge Deck | | |
| | | | | HM | 9 | Prestressed Concrete I-Girder | 18.3 | |
| | | | | HM | 10 | Prestressed Concrete I-Girder | 12.2 | |
| | | | | MBG | 11 | Prestressed Concrete Box Girder (Post Tension Type | 30.5 | |
| | | | | MBG | 12 | Prestressed Concrete Box Girder (Post Tension Type | 24.4 | |

The standard drawing for specified load which does not exist will be prepared by RDSO near future.

As the study for maintenance, rehabilitation and research works are also carried out by RDSO, potential high technique of Indian Railway will be appreciated.

Regarding selection of steel bridge or concrete bridge, tendency to use concrete bridges because then ballasted track can be used on bridges. But as the dead load of concrete bridge is heavier than the steel one, the selection will be done after the economic comparison.

### (3) Design Conditions

According to the above Design Cords, Loading conditions which should be considered for Bridge design are shown on Table 4-8. Detail specification of Live load is shown on

Table 4-9. As the live loads are specified every gauge size and axle load with Equivalent Uniformly Distributed Load (EUDL), the cords are concerned for the practicality. The said standard drawing follows these live loads.

**Table 4-8 Loading conditions to be considered for Bridge design**

| | |
|---|---|
| 1 | Dead load |
| 2 | Live load |
| 3 | Dynamic effect (Impact) |
| 4 | Force due to curvature or eccentricity of track |
| 5 | Temperature effect |
| 6 | Frictional resistance of expansion bearing |
| 7 | Longitudinal forces |
| 8 | Forces on parapets |
| 9 | Wind pressure effect |
| 10 | Forces and effects due to earthquake |
| 11 | Erection forces and effects |
| 12 | Derailment loads |
| 13 | Load due to Plasser's Quick Relay System (PQRS) |

**Table 4-9 Detail specification of Live load**

| Gauge | | | Broad Gauge (1676mm) | | Metre Gauge (1000mm) | | | | Narrow Gauge (762 mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | | | Modified BG Loading | Heavy Mineral Loading | Modified Metre Gauge Loading | Standard M.L. | Standard B.L. | Standard C | Heavy class Loading | 'A' class Main Line Loading | B' class Branch Line Loading |
| Description | | | MBG Loading -1987 | HM Loading | MMG Loading -1988 | ML | BL | C | H | A | B |
| Issued at | | | 1987 | | 1988 | 1929 | 1929 | 1929 | | | |
| Load | Locomotive | (t) | 25.00 | 30.00 | 16.00 | 13.20 | 10.70 | 8.10 | 9.70 | 8.10 | 6.10 |
| | | (kN) | 245.20 | 294.20 | 156.90 | 129.40 | 104.90 | 79.40 | 95.10 | 79.40 | 59.80 |
| | Train | (t/m) | 8.25 | 12.00 | 5.50 | 3.87 | 3.87 | 3.87 | 2.83 | 2.83 | 2.83 |
| | | (kN/m) | 80.90 | 117.70 | 53.90 | 37.95 | 37.95 | 37.95 | 27.80 | 27.80 | 27.80 |
| | | (t) | | | 14.00 | | | | | | |
| | | (kN) | | | 137.29 | | | | | | |

## 4.4 ELECTRICAL FACILITIES

### General

To clarify and understand the points pertaining to traction power, various data were provided from the railways in response to the technical questionnaire from the Study Team. Visits were made to four traction substation sites and one sectioning post and their operating conditions were observed.

1) Eastern Railway Headquarter (***Kolkata***)

- General assembly and technical discussion
- Field survey at Barasat AC 25 kV Traction Substation

2) South Eastern Railway Headquarter (***Kolkata***)

- General assembly and technical discussion

3) Western Railway Headquarter (***Mumbai***)

- General assembly and technical discussion
- Field survey at Palghar AC 25 kV Traction Substation
- Field survey at Andheri DC 1.5 kV Traction Substation

4) Central Railway Headquarter (***Mumbai***)

- General assembly and technical discussion
- Survey in **SCADA** in operation and discussion there

5) East Central Railway ***Mughal Sarai*** Division (***Mughal Sarai***)

- General assembly and technical discussion
- Field survey at Mughal Sarai **SCADA** in operation

6) East Central Railway ***Mughal Sarai*** Division

- Field survey at outdoor-type Sectioning Post
  ex ***Mughal Sarai*** Passenger Station

7) Northern Railway Headquarter (***New Delhi***)

Date: 31 July 2006
- General assembly and technical discussion

### 4.4.1 Present State of Existing Electrified Sectors in Zonal Railways

In these field visits, four AC 25 kV traction substations and one DC 1.5 kV traction substation were surveyed. Also, visits to two SCADA centres were made. At all sites, the intake power system was entirely standardised and identical, either to take in 220 kV or 132 kV single phase transmission. The officers managing the power system stated that the intake power is stable and interruption of power was never experienced in the recent years. Their railway operations have scarcely been hindered to date due to any equipment failure or due to lightening strike on the facilities.

Each traction substation proved to be connected to the nearby power grid that is formed with multiple substations and power stations. Two single-phase intakes are secured in parallel configuration. Connections to such grid greatly contribute in stabilizing the intake power at any traction substation, i.e., the amount of fluctuations of voltage and frequency is minimized at all times. Even in the necessity of extension of the traction power beyond the feeding section, it is directly extensible as there is no displacement of phase angle to each other.

The site investigation of the Study Team did not observe any Automatic Transformer (AT) or Booster Transformer (BT) system within the visited areas. Power feeding was made by the simple catenary system in subject areas. But, there are some sections where conventional DC 1.5 kV traction power system were utilised. As compared to that of AC traction power system, DC equipment is rather cumbersome in its construction of switchgear in addition to the rectifier facility. The officers of the Zonal Railways stated that such DC traction equipment is planned for replacement within the next five years.

It was found that every equipment supervision and switching operations were fully undertaken by the SCADA system in the Headquarter. As compared to the operator-attended substation, this greatly enhances the accuracy and safety of each operation at all times. The Study Team has noted that the architecture of the SCADA was not uniform among Zonal Railways.

### 4.4.2 General View on Traction Power Facilities of the Status Quo

Railway is a multifarious technological system. They are organised and systematically managed exclusively for the operation of rolling stock. Although it is a part of this complex system, traction power supply has its essential roles. This depends on their entirety as well as uniformity of power supply system where the intake of power is made. Regularly, traction power is fed to the electric cars through catenaries directly from each substation or via sectioning post installed alongside the railway tracks.

In order to maintain the routine without failure, the system is thoroughly verified and standardised on their circuit configurations including the incorporation of auxiliary protective devices. Diagram in Fig. 4.15 shows a typical electrical single line applicable to all Zonal Railway. Their power equipment and main apparatus are all outdoor type, and their metering as well as protective devices are all housed in metal enclosed cubicles installed in the cabin. The devices are all locally made.

Thus, the supervision and the control of the equipment of all traction substations and sectioning posts, etc. are consolidated at the Centre on real-time basis. The centralised computer aided SCADA system is used widely for exclusive supervision as well as control for traction power on Indian railways. The adoption of SCADA has contributed to the reduction of mal-functional operation which were apparent on previous scattered control system at each substation.

The main switchgear on the traction power circuits is also locally made. The majority of the power circuit breakers are of vacuum interrupter type. Some breakers still are obsolete types of minimum oil type or SF6 gas type. The officer in charge of traction power stated that these obsolete circuit breakers are being renewed and would entirely be changed to vacuum circuit breakers in a short term.

Although equipment was obsolete, it has been well maintained for the proper function by the maintenance crew assigned to the substation. The Study Team was informed that the maintenance crew has been trained in house so as to be able to cope with any type of repair work. At some sites, the manufacturer dispatched engineer was stationed full time both for the field training of attendants and in addition to monitor their equipments.

It was intimated that the distance to the next subsequent substation is approximately 50 km. The distance of existing traction substation is considered adequate enough to feed traction power to rolling stocks within the permissible voltage drop. The amount of such dip is approximately below 10%, in general. From the standpoint of voltage dropping along the catenaries, it is not practical to assess the distances of traction substations are sufficient or not. It still remains that the 'ohmic loss' induced on the existing conductors are verified to be minimum at present.

Each substation has a secured ample space, in which the enhancement of traction power is feasible for the DFC. However, the connecting public road to each substation seems insufficient and the level crossings will hinder the train speed, greatly.

At present in each traction substation, the installed capacity of a power transformer ranges from 12.6 to 20 MVA as a unit capacity. Even if the average efficiency of a transformer is roughly estimated to be 99.2%, its inherent loss may be roughly 100 to 160 kW as its rated condition. Looking from the standpoint of the energy consumption, the loss is considered too big to be negligible. It will be a matter of further investigation to take up the no-load loss of the traction transformer at each substation.

Regardless of the Zonal Railway visited, except the transformer ratings, the electrical single line diagram obtained during the visit of the Study Team is identical to each other with regard to equipment arrangement. A typical configuration for AC 25 kV system is attached herewith for its clarification.

In case the enhancement or the renovation of existing substation facilities becomes necessary for the implementation of the DFC, Study Team views are that minimal replacement or rearrangement of power transformer(s), switchgears and control-gears will be required.

**TYPICAL OF TRACTION POWER SUPPLY FEEDING ARRANGEMENT**

FIG. 1.01
(PARA 20100)

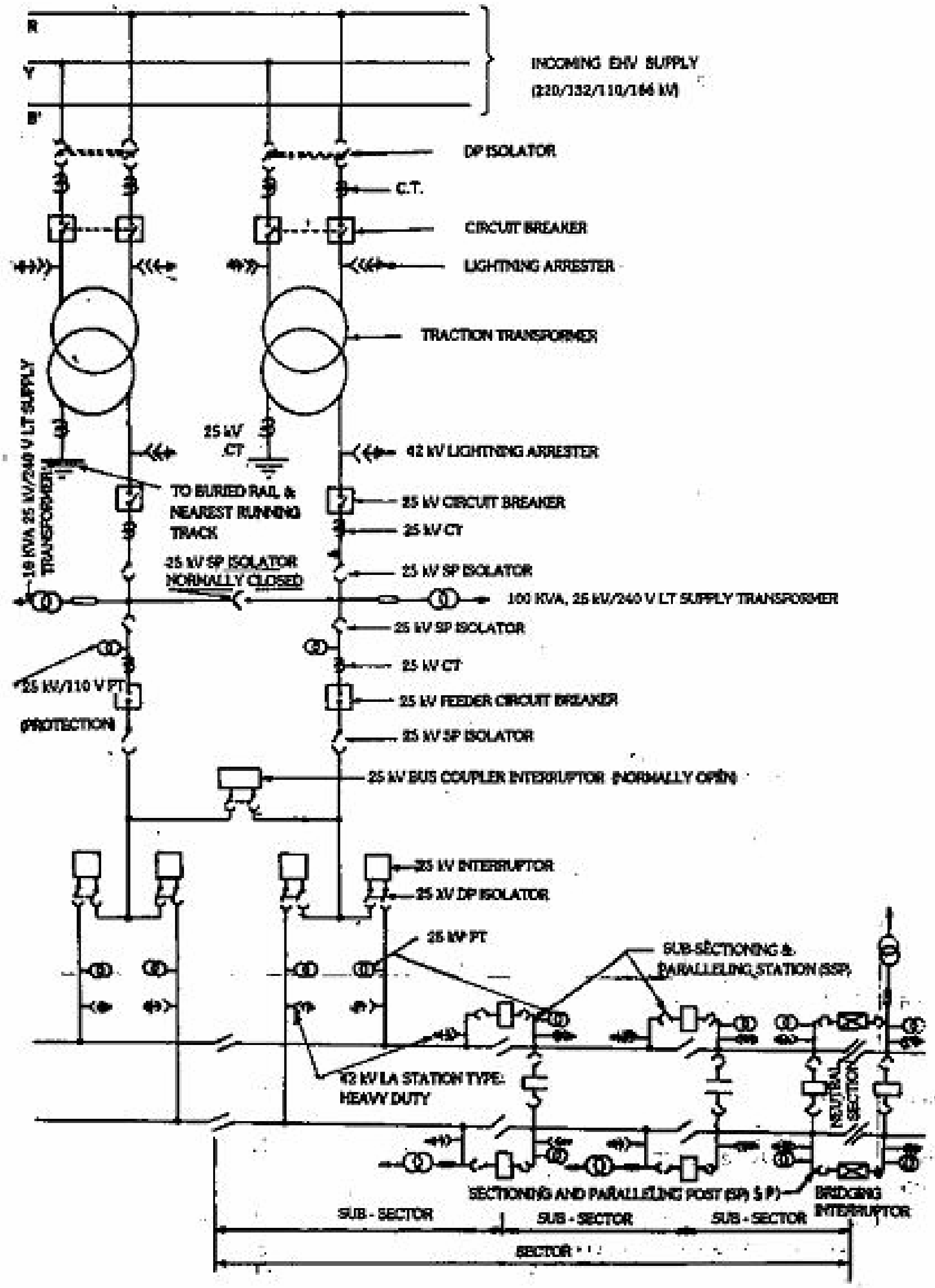



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**Figure 4-12 Electrical Single Line Diagram**

### 4.4.3 Present Power Supply Condition over Non-Electrified Sectors

During the site investigation of the two main corridors, the Study Team was informed by most Zonal Railways of the status of power supply from the power grid to the respective railways. None of the Zonal Railways reported any power shortage or failure over their railway division as the railways has established its first priority in receiving the electric power through years of transaction with power companies.

Further, the Study Team collected reliable statistical data on the growth of installed power generating capacity and power demands. The data indicates that, upon the entire completion of the DFC project, the required electric power will be supplied sufficiently from the nationwide power grid. The Railways has first priority for securing power by the Government. From these objective aspects, it can be said that the power supply condition for the Railways are optimistic.

Domestic as well as imported coals as the fuel for the thermal power plants are abundantly supplied for the power generation. The recent commissioning of a large hydro-power project is pushing up the supply capacity nationwide. The existing non-electrified sections of the DFC corridor would require power, the requirement of power supply can be sufficiently secured with the abundant generation by thermal, hydraulic and nuclear resources (116 GW as of in year 2004-05).

Recent official report clarifies that the installed generated power in India will reach 200 GW in total, which is considered to be capable of sustaining the full operation of the DFC even upon its commissioning. Facilities installed on each Zonal Railway are flexible in each component that the supply of traction power could meet the demand by replacement of the main transformers.

### 4.4.4 Regulation against Electromagnetic Induction and Harmonics in Indian Railways

Railways are apt to become the major source of disturbances to signalling as well as communication systems. Mainly, there are two different phenomena of disturbance or interference that affect these systems. As for the basis of countermeasure against the disturbance by the electromagnetic induction and harmonic waves, Indian Railways have already established the regulations (Harmonic wave's regulation) for the suppression against such interference.

The former is the electrostatic induction that induces a certain amount of voltage on the cables laid in parallel to the catenary. The induced voltage is proportional to the traction voltage, and the voltage is to be regulated to the value to avoid the danger to a human body and the equipments.

The latter is the electromagnetic induction voltage that is induced by the traction currents in proportion to the longitudinal distance of the communication lines laid parallel to the catenary.

Present regulation on the induced voltage by the electromagnetic induction is 60V and is the limit value at the normal state, and 430V for incidental abnormal case such as by an earthing fault. These limits are the same as those applied in Japan (Refer below). However, this is not necessarily taken up for discussion, since the existing traction is single phase 25kV AC. Though the extent of disturbance or interference is largely affect the communication system as compared to that of by DC traction system, any trouble is said to be rare due to the limited amount of communication lines running parallel to the catenary.

The most suitable and effective measure for the suppression of electromagnetic interferences will be elaborated and determined for the traction power system of the DFC. It will be one of the major factors that would determine the most suitable system for the DFC project.

The regulation has become rather superannuated and the regulated values are not necessarily valid for up-to-date sensitive electronic equipments. It is preferable that the regulation against the electromagnetic induction and harmonic waves will be revised suitably and also reinforced so as to mitigate all kinds of influence induced by such phenomena on the railways. For the discussion of such technical solution the regulation applied in Japanese railways may be of some reference.

**Table 4-10 Limits of Induced Voltage due to 25kV AC Electrification**

| | |
|---|---|
| 1. | Longitudinal induced voltage on DoT lines due to railway electrification shall not exceed 60 V under normal working conditions and 430 V under faulty conditions. |
| 2. | The limit of 5V shall be applicable only for transverse induced voltage on the DoT lines. |
| 3. | The rail screening factor shall be 0.28 where all four (4) rails are conducting on a double track section. |

## 4.5 TELECOMMUNICATION SYSTEM

Telecommunication systems have an essential and important role in railway operations such as train control, operation, safety, etc. In order to meet operational demands, Indian Railways is in the process of improving and expanding their telecommunication systems. The following information describes the current situation and trends in telecommunications development within Indian Railways.

- Optical fibre communications (OFC) systems have been selected as the next generation fixed telecommunication system because of capacity and quality (EMC: electromagnetic compatibility) advantages offered by OFC. For this purpose, a total of 42,000 route km of Optical Fibre Cable (OFC) network with Synchronous Transfer Mode (STM) are planned to be commissioned by March 31, 2008. In addition, most of 7 GHz digital microwave system is operated as a back-up communication system.
- A 150 MHz band press-to-talk mobile radio system is provided for the purpose of making emergency calls. However, the operational mode (press-to-talk operation) and low communication quality (due to noise) does not satisfactorily meet operational requirements. Therefore, with the aim of ensuring stable communications between train crews and station operators (Station Masters, Controllers, field maintenance staff, etc.), a Global System for Mobile Communication (GSM) based mobile communication system is being introduced on the ‘A’, ‘B’ and ‘C’ routes of Indian Railways and some of these system have already been operated. In addition, the contract for installing 2,415 route km of GSM-R has been awarded.
- All the Zonal and Divisional exchanges of Indian Railways are being integrated under a uniform standard via 2 MBPS connectivity. For this purpose, Indian Railways is now replacing analog exchanges with digital exchanges. A total of 274,034 subscribers were connected to digital exchanges by March 2005 and 38,469 of these subscribers were connected in 2004-05.
- RailTel Corporation was established in 2000, and it has started earning revenue by marketing the excess bandwidth available in communications facilities such as the Optical Fibre Cable (OFC) network and other infrastructure. The revenue earned during 2004-05 was estimated at Rs.350 million (Rs. 35 cr.).

### 4.5.1 Existing Telecommunication Systems

#### (1) Outline of the telecommunication systems

With the changing of telecommunication technology, Indian Railways has improved and expanded their telecommunication systems in order to create a more reliable and more effective communications environment. Table 4-11 below shows the progress of Indian Railways telecommunication systems development as of March 2005.

**Table 4-11 Existing Telecommunication Systems**

| System | Unit | As of March 2004 | As of March 2005 |
|---|---|---|---|
| Digital Electronic Exchanges | Line | 235,565 | 274,034 |
| Control sections provided with Dual Tone Multiple Frequency (DTMF) control equipment | No. | 292 | 292 |
| Digital Microwave (7GHz) | Route km | 7,093 | 7,093 |
| Control communication through wireless (18GHz) | Route km | 989 | 989 |
| Mobile train radio communication system | Route km | 1,686 | 1,686 |
| Optical fiber communication (OFC) system for control communication | Route km | 16,089 | 22,423 |
| Microprocessor-based public address system | Stations | 588 | 674 |
| Electronic train display boards | Stations | 363 | 395 |
| Interactive voice response system for train inquiry/reservation status | Stations | 365 | 428 |

Source: Indian Railways Year Book (2004-05)

#### (2) Current condition of zonal telecommunications

Through site survey and interview of Ministry of Railways, Research Design & Standardisation Organisation (RSDO) and Zonal Railways of Western, Central, East Central, Northern and North Western, the Study Team confirmed the following situations of the telecommunication system.

**Table 4-12 Current Condition of the Zonal Railways**

| Type of System | Current Condition |
|---|---|
| Fixed communication | 1) Optical fibre communication (OFC) system with STM is provided in almost all management areas, except feeder routes as follows;<br>For trunk lines: STM-16 (1+1 system)<br>For branch lines: STM-1 or STM-4<br>2) The standard number of optical fibre cores is 24 cores. This value is standardized in throughout India.<br>3) Digital microwave (7GHz) with 496ch is operated as backup for the OFC system<br>4) 18GHz radio system was installed section between Howrah-Pradahankhanta-Mugalsarai (approx 700 route km) during year 1985-90 for the purpose of anti- vandalism. |
| Mobile commutation | 1) For voice communication, Global System for Mobile Communication for railway applications (GSM-R), with dedicated 10ch capacity is operated.<br>2) 150MHz band press-to-talk mobile radio system is provided for the purpose of making emergency calls. However, communication quality sometimes does not meet operational needs due to noise.<br>3) In some management areas of Eastern railway, there is difficulty to install usual emergency telephones due to vandalism. In such condition, mobile communication such as GSM (Public GSM) mobile phone and 150MHz radio are utilized in this section. |
| Others | 1) Emergency telephone equipment is installed at 1km intervals along the rail tracks.<br>2) For emergency telephone and level crossing control, communication cables (0.9mm x 6Q or 4Q) are provided. |

### 4.5.2 Development Tendency and Directivity of the Telecommunication Systems

#### (1) Optical Fibre Cable Network

Indian Railways has a policy of applying state-of-the-art technology to their nationwide telecommunication network to meet essential communication needs and also for earning revenue by exploiting the excess capacity commercially. For this purpose, RailTel Corporation was established in September 2000 with the aim of developing the telecommunication network of Indian Railways as scheduled. A total of 42,000 route km of Optical Fibre Cable (OFC) network having a Synchronous Transfer Mode (STM) is planned to be commissioned by 2008. Out of these 42,000 route km, approximately 27,100 route km of OFC was installed and 2,092 railway stations were linked with OFC, as of March, 2005.

In addition, RailTel plans to develop cyber cafes at all important railway stations in a stage-wise development manner. In Phase-I, 82 stations were planned to be covered with 42 cyber cafes by March 2006.

RailTel has started earning revenue by marketing the excess bandwidth and other infrastructure. The revenue earned during 2004-05 was estimated at Rs.350 million (Rs. 35 Cr.). The Optical Fibre Network Plan as of June 30, 2006 is shown in Figure 4-13.

#### (2) Mobile Train Radio Communication (MTRC)

To meet communication needs between train crews and station operators (station masters, controllers, field maintenance staff, etc.), a Global System for Mobile communication (GSM) based mobile communication system is being introduced on the ‘A’, ‘B’ and ‘C’ routes of Indian Railways.

This system is known as a Global System for Mobile Communication for railway applications (GSM-R). GSM-R is an indispensable component system of the European Rail Traffic Management System (ERTMS) and European Train Control System (ETCS), and it has been standardized under the European Integrated Railway Radio Enhanced Network (EIRENE) project.

GSM-R development for over 3,200 route km has been approved by Indian Railways for their Northern, North Central, Eastern, East Central and Northeast Frontier railway lines. These GSM-R facilities are planned to be commissioned by 2008 and some of these system have already been operated.

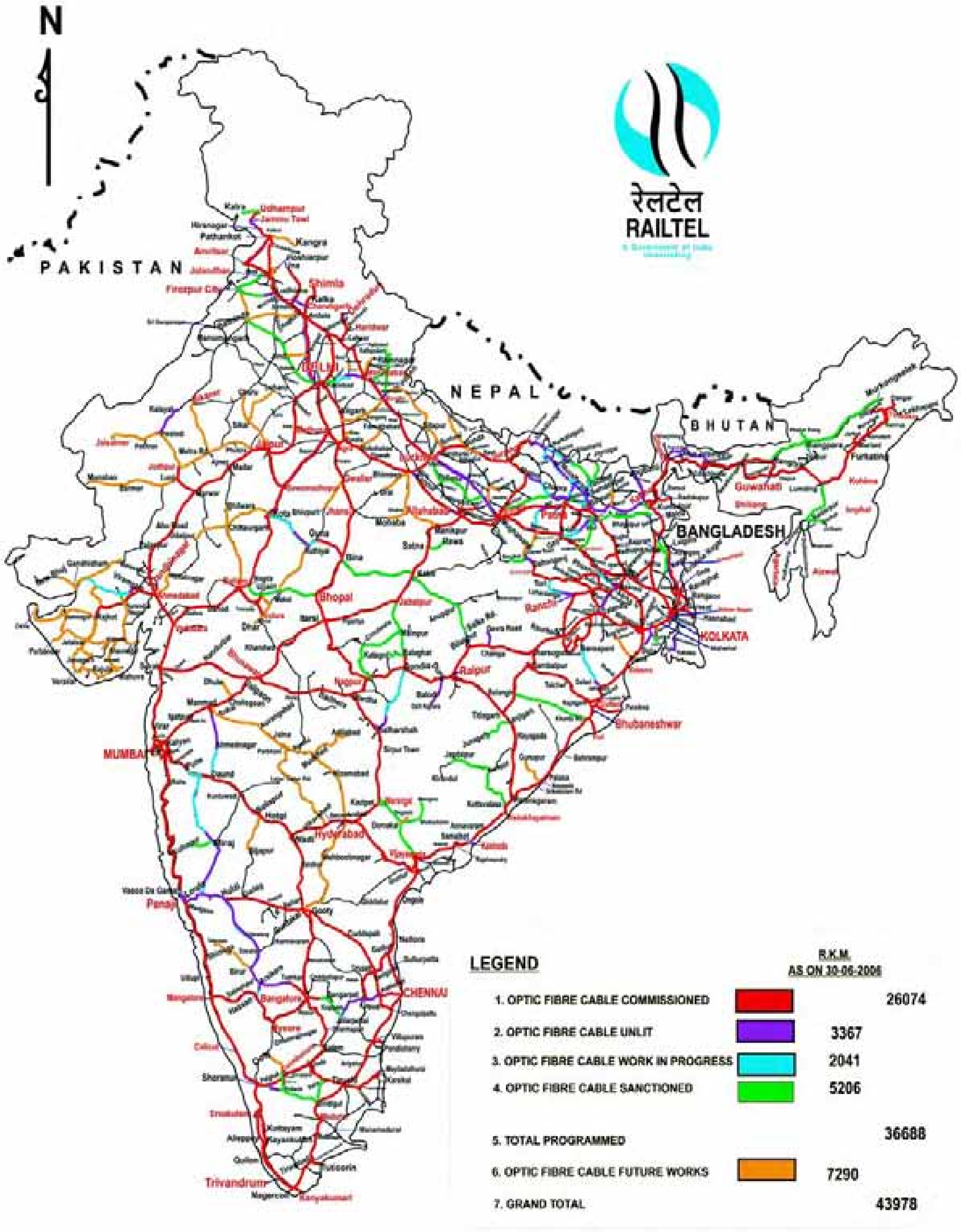
In addition, development of GSM-R for 2,415 route km is stated in the "Integrated Railway Modernization Plan (2005-10)" and the development contract for this project has already been awarded.

### (3) V-SAT (Very Small Aperture Terminal)

In order to secure communications in remote areas that lack conventional telecommunication facilities, Indian Railways is introducing its own V-SAT system throughout the country. The V-SAT hub is located in New Delhi and it provides point-to-point communications to meet voice and data communication requirements. In the Indian Railways Year Book (2004-05), 220 remote sites are listed as being planned for connection with the Freight Operations Information System (FOIS) network of Indian Railways. V-SAT facilities at some of these sites have already been constructed.

### (4) Switching and Data Networks

Indian Railways is now replacing its old analog exchanges with digital electronic exchanges to improve the quality of switching and reduce the maintenance burden. The total number of digital subscribers had reached 274,034 as of March 2005, and 38,469 of these subscribers were connected to digital exchanges during the year 2004-05. All the Zonal and Divisional exchanges of Indian Railways are being integrated for seamless connectivity by providing a 2 MBPS interface.




Source: RAILTEL Corporation of India[1]

**Figure 4-13 Optical fiber network plan as of June 30, 2006**

1 *http://www.railtelindia.com/networks/OFC-as-on-June-06.gif*

## 4.6 SIGNALLING SYSTEM

The Study Team visited and interviewed 5 Zonal Railways regarding the condition of existing signalling system. Site survey confirmed that the condition of Indian Railway's existing signalling system presented in the RITES Preliminary Engineering Study. Each Zonal Railway adopts the standard signalling systems which are standardised by RDSO (Research Design & Standards Organization), and the basic block system is absolute block system.

Currently, the Zonal Railways are introducing automatic signalling and block system in rural area, where 4 aspects multiple colours signal is provided. However, in the most of area, the absolute block systems are applied. The Western Railway is introducing automatic signalling in Mumbai suburban area; Northern Railway is currently modernising the signalling section between Ghaziabad and Kanpur.

Also electronic interlocking system integrating signals, switch machines, level crossing gates etc. are in process, however, many old types of manually operated equipment are still functional.

There are some factors which are constraining the line capacity of railway, such as limitation on running speed of trains in station yards, manually operated level crossing gates and interlocking by means of voice communication between dispatcher and operator.

### 4.6.1 Existing Signalling System

Many types of interlocking system are utilized on the Indian Railways, and the typical systems are indicated as follows.

#### (1) Mechanical Interlocking System

The system comprises of a mechanical interlocking frame having locking arrangement between the operating levers of signal, switches and slot etc. The necessary interlocking between the operating levers is achieved by means of lever attached tie bars, cross tie bars and different dogs. The system is totally mechanical based and requires intensive maintenance and testing. This system should be replaced to electronic Interlocking system hereafter.

#### (2) Route Relay Interlocking/Panel Interlocking

In this system, the required interlocking between signals, switches, level crossing gates, etc. is achieved by means of electrical relays. Normally in this system point switch operation is achieved by electric point machine, track section detection by provision of track circuits etc. The operation panel is provided to set the required route and take off the corresponding signal. The panel depicts replica of the station yard and with the help of indication provided, the actual train operation can be observed on the panel. A large number of relays and corresponding wiring is required to be done in the relay room. This system will be replaced by Electronic Interlocking system from outdated ones, according to the modernisation plan.

#### (3) Electronic Interlocking System

This system is already installed in 73 stations in 2005 according to IR Year Book. This system achieves the interlocking between signals, points, level crossing gates etc. through microprocessor based logic. The operation/display unit may either consist of panel or a P.C. monitor with keyboard/mouse. The provision of man-machine interface makes system more operating friendly.

### (4) Absolute Block

This is a block system, which ensures only one train in the block section at a time. This is achieved by means of signal/double line lock and block instruments. One pair of instruments are installed the two adjacent stations of a block section through physical medium/safe multiplex connectivity. Each instrument is interlocked with other side instrument and "Advance Starter" and "Home" signals of the stations. The instruments have the handle which can go to positions indicating "no train in the block section, "entry of train in the block section" and "clearance of the train from the block section".

This system is desirable to be replaced to automatic block system or intermediate block system where line capacity needs to increase.

### (5) Automatic Block System

In this system the block section is divided in smaller automatic sections by means of continuous track circuiting and provision of automatic signals. The automatic signal assumes the "off" aspect, whenever the adequate distance ahead of it is clear. This system therefore increases the line capacity. In automatic signalling system the normal aspect is green, whereas in absolute block system it is red.

### (6) Intermediate Blocking system (IBS)

In the long one block section, the capacity of entire line is limited by the required time to run through this block section. This section is divided into two sections with signal in intermediate location of this long section by means of block providing axle counter etc. Block clearances are processed independently for the two sections, and Indian railway has installed more than 100 units of IBS. This is one of the quicker ways to increase the line capacity.

### (7) Multiple Aspect Colour Light Signal

This signal is provided four colour light "yellow, red, yellow and green", and the arrangement of this signalling is distance signal. Two set of signals are located this side of home signal of station, and 1st one is 1 km to 1.5 km apart from home signal and the 2nd one is apart at the same distance from 1st one. Two signals act as distant signal indicating the aspect of the next signal, where one "yellow" means the "red" aspect of the next signal and "yellow + yellow : two yellow" means the "yellow" aspect of the next signal. When the home signal turns "red" aspect, i.e. the next block section is not clear, two signals automatically indicate "yellow" and "yellow plus yellow" respectively. The installation of the second distant signal will contribute in improving the safety of operations.

### (8) Signalling Systems in Zonal Railways relevant to DFC

During the Study Team's visit of 5 Zonal Railways, and interviewing the officer's in charge of the signalling system regarding the condition of existing signalling systems, and also carried out site survey.

Central Railway Headquarters
Western Railway Headquarters
East Central Railway Mughal Sarai Div.
Northern Railway Headquarters
North Western Railway Headquarters

The adopted systems in Eastern and Western corridor are shown herein.

Western Corridor

1) Palwal-Mathura

Automatic signal (4 aspects MACLS)
Axle counters for detection of train occupancy
Approach locking system for level crossing with RTU

2) Mathura-Nagda

MACLS with panel interlocking system
Standard 3 interlocking system
Block proving by BPAC (block proving axle counter)

3) Nagda-Godhra

MACLS
Relay based interlocking system with central panel in way-side stations
Data loggers for on-line monitoring and taking remedial measures at all stations

4) Godhra-Surat

Panel interlocking in most of station,
Route relay interlocking at Vadodara and Surat station
Standard 3 interlocking in all station
SGE double line block working
DC track circuit
Independent interlocking level crossing

5) Vasai Road-Surat

MACLS
Standard 3 interlocking in all station
Route relay interlocking and relay based panel interlocking
Fully track circuited by DC track circuit or AFTC (audio frequency track circuit) in station yards
SGE double line lock and automatic signalling
Data logger in all stations
Telephone communication for level crossing
Interlocked out-side level crossing and un-interlocked out-side level crossing
Most of in-side level crossings are interlocked with the station signals.

6) Vasai Road-JNPT

Single line (Panvel-Navasheva)
Standard 1 and 3 interlocking
Token-less Podunur push button type block working
Route relay interlocking in Panvel station
Double line
Standard 3 interlocking
SGE lock and block instrument
Central RRI (route relay interlocking) at Dativli station
Track circuit for panel working

7) Madar-Karjoda

MACLS controlled from central control panel
DC track circuits in station yards
Level crossing interlocked with station signals (partially)

8) Sabarmati-Palanpur

Panel operation with MACLS
DC track circuit
Token-less block instrument

Eastern Corridor

1) Kanpur-Mughal Sarai

CLS (colour light signal)
Electro-mechanical system in most of stations
Absolute block system by SGE double line block
All level crossings (Class A, B and C) are manned and provided gates and are controlled by nearest station master.
Mechanical lever frame for operation of point, lock and signalling at most of stations

2) Mughal Sarai-Manpur

MACLS
SGE double line block and block instrument
Panel interlocking in most of way-side stations
Mechanical lever frame in Gaya and Son Nagar junction
Operation from stationmaster centrally or end cabins
Level crossing control by stationmaster with voice
No warning bell
Provision of hooter and road signal for 21 level crossing

3) Manpur-Gomoh

MACLS
Absolute lock and block system and standard 3 interlocking
Provided End panel/Centre panel/RRI except for Koderma station
DC truck circuit
Block-huts provided with control panel
Manned level crossing provided magneto-telephone with nearest Stationmaster/cabin
Level crossing gate interlocked with signal/un-interlocked
All the level crossing gate are mechanically operated and are not provided any hooter and road signals.

### 4.6.2 Issues of Signalling Systems

The issues of existing signalling systems are as follows;

1) Dissemination of modernised and automated of signalling

The absolute block system is the prevalent method of train working on the Indian Railways. Automatic signalling and block system in suburban areas have seen its introduction, combined with the introduction of colour light signals and automatic warning system, however block sections are long and non-automatic systems still remain. Further dissemination of modernised and automation of signalling by the Indian Railways are necessary.

2) Introduction of Automatic Train Detection Measures

The Indian Railways are enhancing the level of safety in train by upgrading the signalling systems through installation of colour light signalling, track-circuiting, automatic block signalling, automatic train protection and warning, block proving by axle-counters, panel and solid state interlocking and ACD.

The enhancement of capability to physically confirm the occupation and clearance of trains on tracks by means of automatic train detection devices such as track circuit and axle counters have become priority since the tragic accident at Ferozabad station of Northern Railway in 1995. Since manual operations are prone to human error, compromise of safety is imminent. Introduction of automatic train detection as well as computer based centralised traffic control are one of the effective measure to eliminate these risk. These devices have yet to be disseminated across the main lines of all important corridors of the Indian Railways.

3) Promotion of Introduction of Automatic Level Crossing Control

A large number and various types of level crossing exist along the subject route, of which some not being provided any protection for train, road traffic, or both.

The Indian Railways provides the following protective measures for their level crossing as follows;

- Interlocking between protection signal and level crossing gate
- Interlocking between starter signal of station and level crossing gate, directly controlled by station master
- Controlled by station master by means of voice communication with level crossing operator
  (There are two types of crossing gate; motor drive type and manual operation)
- Normally open (in the case of heavy road traffic)
- Normally closed (in the case of light road traffic)

There are a number of level crossings which are not provided with any warning equipment or signals against road traffic, and these level crossings are a great threat to safety both of railway and road traffic.

When the trains pass the level crossings without any train protections, the train drivers are instructed to drive train slowly and to confirm the safety of running, and the controlling by means of voice communication between station master and level crossing operator causes longer waiting time of trains in station yards, consequently the line capacity is limited. And also this longer waiting time of train causes long time of interference against road traffic.

4) Other improvements required for the line capacity

The limitation in speed of running through of trains in station yards may be suffocating the line capacity of railway.

The running time of train between adjacent stations (one block section) is the dominant factor which limits the line capacity now, therefore the required time for the running through station yards is not so critical for line capacity.

However, when Indian railway will adapt the multi-block system in future for increasing of the line capacity, where the block distance will be 1 km or 1.5 km, it will again fall in serious condition since the running through speed of train in station yards is limited within 10 or 15 km/hour. This issue will be more critical in the case of junction stations with longer station yards.

In addition the train drivers are compelled to drive the trains slowly to conform to the safety of running in a station yard and around a level crossing, because the passengers and neighbouring persons are using the wayside as a path everyday. And also the domestic animals are entering into rail lines way-side; consequently the train can not run at the allowable speed.

### 4.6.3 The Modernisation Plan of Signalling System

Modernisation of Signalling Systems is planning as follow.

- Replacement of outdated Signalling Assets by Relay or Solid State Interlocking with Data loggers.

  It is proposed to wipe out the arrears at about 700 stations sanctioned by March 2007.

- Complete Track Circuiting at all Block Stations on A, B, C, D.and E Special routes.

  Work at 2722 locations is targeted to be completed by March 2007.

- Train Protection and Warning System (TPWS)

  This system prevents the case of Signal Passing at Danger (SPAD) and averts derailment/collision. The works are targeted to cover 300 R km by March 2007.

- Provision of Block Proving by Axle Counters (BPAC)

  This will be installed in the portion of track between two block sections for ensuring the clearance of block section. BPAC is targeted for completion in March 2008 on about 1350 block sections.

- Anti-Collision Device (ACD) with SPAD protection feature

  ACD's will be installed to prevent SPAD and avert train collision. A total of 52,600 Rkm will be covered by March 2014. ACD is already installed on 1740 km over North Frontier Railway.

- Continuous Track Circuiting

  To enhance the safety in the section between two block stations, and increase line capacity, continuous track circuiting has been undertaken. The work sanctioned on 2000 R km will be completed during the plan period.

### 4.6.4 Ongoing Modernization Plan in the Section Ghaziabad-Kanpur and other section

#### (1) Ghaziabad-Kanpur Section

1) The line capacity will be increased more than 150 % from the existing, and the safety of operation also will be enhanced.
2) 23 of the 48 partial sections of the line are without block signals, and only two sections are equipped with automatic block signalling. The block distance along the line is long and the maximum is about 7 km. The dominant limitation of line capacity is caused by this long block section, therefore the block distance will be reduced and the modern solid state interlocking and automatic block signal on the entire line will be provided. The new automatic block signals will be located with distance of 1.0 to 1.6 km in Ghaziabad to Aligarh section and up to 2 km for the rest of line.
3) The centralized train control system (CTC) by means of solid state interlocking (SSI) will be installed and the CTC centre will be located in Tundla. Local operation will be possible in case of emergency and for local shunting operation,
4) Adoption of continuous track circuit installation throughout the entire line and full integration of level crossing into interlocking.
5) Adoption of automatic block
6) Adoption of LED signals

   All signals will be constructed in a way so that that the ATC can be added on in the future.

7) Adoption of level crossing interlocking

All level crossings will be protected by gate signals which will work as block signals also. The control and locking of the barriers will be controlled and locked mechanically and interlocked by means of electrical key.

8) Adoption of 3 phase AC point machine in larger stations

9) Adoption of axle counter and audio frequency track circuit (AxC) for train vacancy detection

AxC for all stations (main lines excluded)

AFTC for main lines of the stations and on section lines

10) Adoption of un-interrupting power supply for CTC system

The capacity of battery will be sufficient to feed the total load for 4 hours.

The result of this modernization plan of signalling will be expected as follows;

- Ghaziabad-Aligarh section（1.0 - 1.6 km block distance）
  More than 100% increase of line capacity
- Aligarh-Kanpur section
  Clearly more than 50% increase of line capacity

### (2) Other section

1) Kanpur-Allahabad-Mughalsarai

Adoption of centralised electronic interlocking

2) Kodarma Station

Replacement of mechanical lever frame by panel interlocking

Adoption of public address equipment in Paharpur, Gujhandi, Koderma, and Parsabad station

3) New Delhi-Mathura

Up-gradation of signalling arrangement to the level of ETCS-1

4) Mathura-Nagda

Improvement of level crossing

5) Marwar-Palanpur

Installation of axle counters for block working

## 4.7 ROLLING STOCK

India has a well-developed railway industry capable of building electric and diesel locomotives as well as coaches and wagons. It supplies almost all of the rolling stock used by Indian Railways and is exporting these products to developing countries such as Angola, Myanmar and Bangladesh.

The rail technology used was originally introduced by European countries, the United States and Japan and was then modified to meet the specific needs of Indian railways. However, the current rail technology used in India is not the state-of-the-art, as the rail technology used in European countries, the United States and Japan. Since it appears that it would be very hard to fulfil the performance target expected in the DFC project using the present Indian rolling stock, new development will be essential to realise the project.

Discussions with representatives of the Indian Railway make it clear that they are eager to study new technologies and start the development of new systems.

### 4.7.1 Current rolling stock conditions

#### (1) Traction system and number of locomotives

As mentioned previously, 25.78 % of the lines are electrified at 25 kV AC or 1500 V DC. DC electrification is limited mainly to the Mumbai area and will be converted to AC track electrification in next five years.

Table 4-13, Percentage of Train Kilometres by Type of Traction, shows that 46.8 % of passenger and 57.0 % of freight trains are operated by electric traction Table 4-14, Percentage of Gross Tonne Kilometres by Type of Traction, show that 47.6 % of the passengers and 60.9 % of the freight are transported by electric traction.

However, the ratio of the number of rolling stock, especially diesel and electric locomotive shown in Table 4-15 indicates a different trend, meaning that electric locomotives are used more efficiently than diesel locomotives, even if many of the diesel locomotives are used for shunting.

**Table 4-13 Percentage of Train Kilometres by Type of Traction**

| Year | Passenger | | | Freight | |
|---|---|---|---|---|---|
| | Diesel | Electric | | Diesel | Electric |
| | | Locomotive | EMU | | |
| 2000-01 | 56.2 | 31.2 | 12.7 | 43.5 | 56.5 |
| 2001-02 | 54.5 | 31.2 | 14.3 | 43.3 | 56.7 |
| 2002-03 | 53.9 | 32.0 | 14.1 | 42.5 | 57.5 |
| 2003-04 | 53.2 | 32.4 | 14.4 | 43.0 | 57.0 |

From Year Book 2003-04
EMU: Electric Multiple Unit

**Table 4-14 Percentage of Gross Tonne Kilometres by Type of Traction**

| Year | Passenger | | | Freight | |
|---|---|---|---|---|---|
| | Diesel | Electric | | Diesel | Electric |
| | | Locomotive | EMU | | |
| 2000-01 | 52.8 | 40.2 | 7.0 | 40.2 | 59.8 |
| 2001-02 | 51.3 | 40.4 | 8.3 | 39.5 | 60.5 |
| 2002-03 | 50.5 | 41.2 | 8.3 | 38.0 | 62.0 |
| 2003-04 | 52.4 | 39.2 | 8.4 | 39.1 | 60.9 |

From Year Book 2003-04 and Annual Statistical Statements 2004-05

**Table 4-15 Number of Locomotives by Type**

| Year | Number of Locomotives | | | |
|---|---|---|---|---|
| | Steam | Diesel | Electric | Total |
| 2000-01 | 54 | 4,702 | 2,810 | 7,566 |
| 2001-02 | 53 | 4,815 | 2,871 | 7,739 |
| 2002-03 | 52 | 4,699 | 2,930 | 7,681 |
| 2003-04 | 45 | 4,769 | 3,003 | 7,817 |
| 2004-05 | 44 | 4,801 | 3,065 | 7,910 |

From Year Book 2003-04 and Annual Statistical Statements 2004-05

### (2) Types of Locomotives

1) Diesel locomotives

The diesel locomotives used by Indian Railways are shown in Table 4-16. Almost all locomotives on trunk lines are diesel electric. The locomotives used for freight trains are typically in classes: WDG-4 with 4,000 hp, DG-2 and WDG-3 with 3,100-3,300 hp. The latest locomotive is the class WDP-4 with 4,000 hp. It has 6 axles with an asynchronous motor drive and was developed in 2001 using technology introduced by General Motors of the United States.

**Table 4-16 Types of Diesel Locomotives**

| Purpose | Class |
|---|---|
| Goods | WDG-2, WDG-4 |
| Passenger | WDP-1, WDP-2, WDP-4 |
| Mixed | WDM-1, WDM-2, WDM-2C, WDM-2D, WDM-3, WDM-3A, WDM-4, WDM-7, YDM-1R, YDM-2, YDM-4A, YDM-5, ZDM-3, ZDM-4A, ZDM-5 |
| Marshalling, Shunting | WDS-4B, WDS-4D, WDS-5, WDS-6 |

2) Electric locomotives

The electric locomotives used by Indian Railways are shown in Table 4-17. Typical locomotives are the WAG-6 and WAG-9 class with 6,000 hp and the WAG-7 class with

5,000 hp. The latest locomotive is the WAG-9, which has six axles and asynchronous motor drive. It was developed in 1996 using technology introduced by ABB of Europe.

**Table 4-17 Types of Electric Locomotives**

| Purpose | Class |
|---|---|
| Freight | WAG-1, WAG-2, WAG-3, WAG-4, WAG-5(5A, 5B, 5C, 5D, 5H, 5HR, 5HA, 5HB, 5S), WAG-6(6A, 6B, 6C), WAG-7, WAG-9 |
| Passenger | WAP-1, WAP-2, WAP-3, WAP-5 |
| Mixed | WAM-1, WAM-2, WAM-3, WAM-4, WCAM-1, YAM-1 |

### 4.7.2 Current Condition of Maintenance Depots and Workshops

#### (1) Organisation of rolling stock maintenance

An example of typical organisation of maintenance for rolling stock is shown in Figure 4-14. The system is almost the same as found on other Zonal Railways. A similar system will be also introduced to DFC.

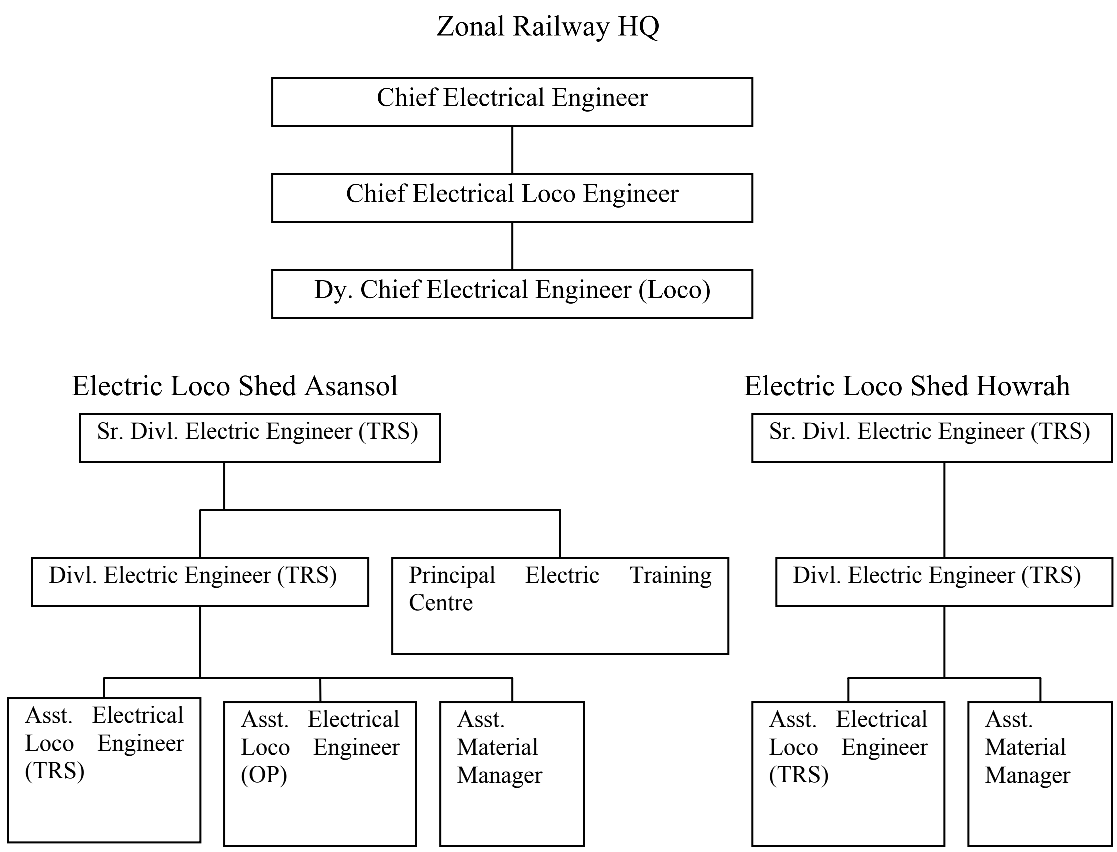



**Figure 4-14 Example of Rolling Maintenance Organisation**

Rolling stock maintenance is done through a combination of periodical inspections and overhauls. This maintenance system is similar to the system used in Japan. However, the scope and interval of the maintenance to be applied to electric locomotive, diesel locomotive and wagon will be different because of the differences in technologies and designs of the rolling stock.

### (2) Allocation of maintenance depots and workshops

The allocation of maintenance depots and workshops for Zonal Railways related with the planned DFC is shown in Figure 4-15.

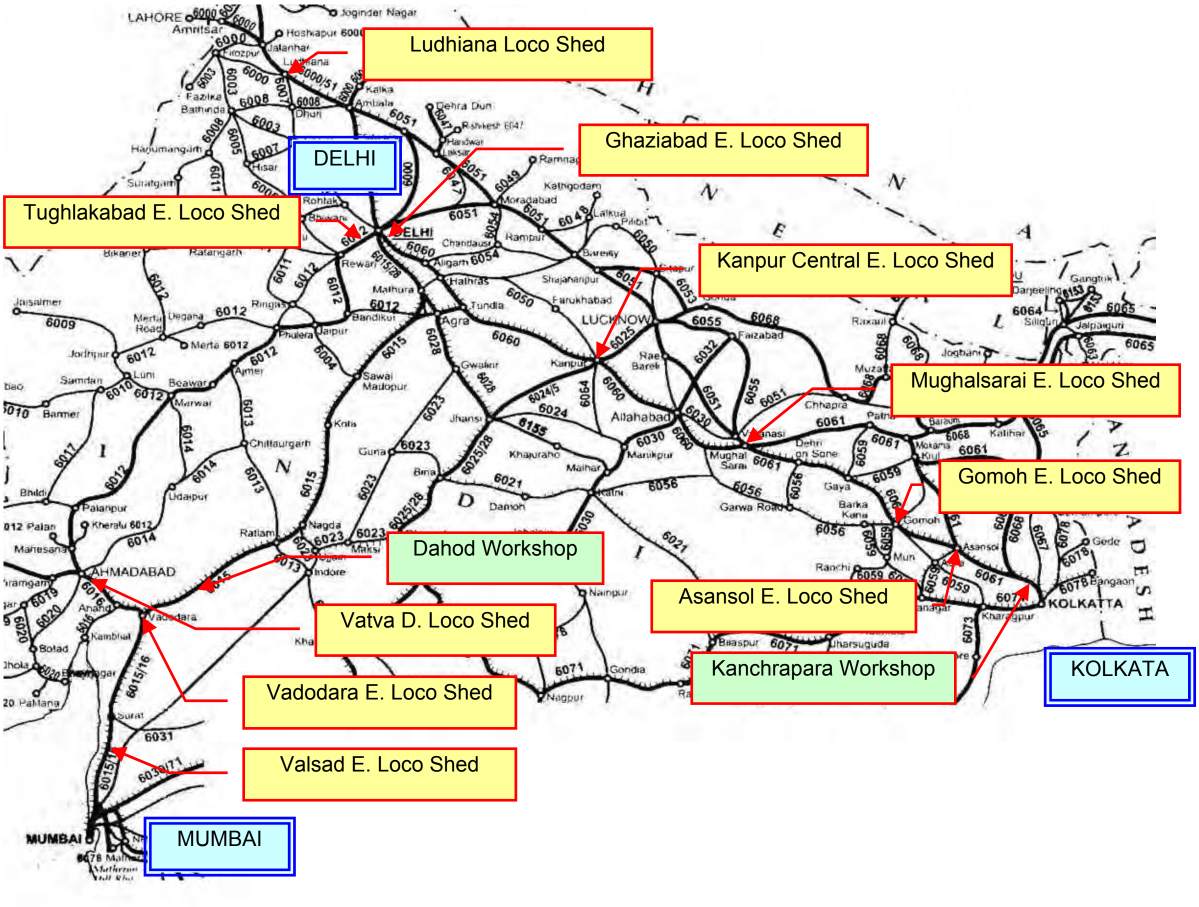



**Figure 4-15 Allocation of depots and workshops**

Site surveys and discussions with relevant representatives for the Zonal Railway's officers related to the DFC route were conducted in year 2006 as follows;

Eastern Railway Headquarters. on 12th July
Western Railway Headquarters. on 18th July
Vadodara Electric Locomotive Shed on 19th July
Dahod Workshop on 19th July
Vatva Diesel Locomotive Shed on 20th July
East Central Railway Mughal Sarai Div. on 24th July
Mughal Sarai Electric Locomotive Shed on 25th July
Mughal Sarai Wagon Maintenance Depot on 25th July
Northern Railway Headquarters on 31st July

Based on the visits to the relevant sites related to DFC, it appears that there is some reserve capacity for inspections, except at the Northern Railway. However, more detailed examination is needed to evaluate investments for depots and workshops according with numbers of rolling stock specified by the transportation plan for DFC.

The management system for rolling stock maintenance is well arranged. Some depots and workshop have introduced ISO 9001 and ISO 14000 systems as shown in Photos 4-1 and 4-2. The ISO quality control system works well in the depots and contributes to reduced failures.

**Photo 4-1 Vadodara Electric Loco Shed**


**Photo 4-2 Example of QC activity at Vadodara Electric Loco Shed**

### (3) The information for DFC Depot facilities and Workshops as existing now

The Mumbai-Delhi route of DFC will be running almost parallel for the present Rajdhani route with alternative route via Vadodara - Ahmedabad-Phulera-Rewari Delhi.

The depot facilities as available on this route are as follows:

1) WESTERN RAILWAY (Mumbai, Churchgate)

Loco sheds are shown in Table 4-18(A) and (B). The Workshops of Western Railway are as under:

1. Lower Parel- for Periodic overhaul (POH) of B.G. coaches.
2. Ajmer- Carriage & Wagon workshop
3. Dahod- B G Electric Loco POH shop

4. Pratapnagar- BG and NG Wagon/coach repair and BG Oil tanker repair shop.

**Table 4-18 (A) Electric Loco sheds on WR**

| Location | Type of Locomotives maintained at present | Capacity | Present holding | Constrains/ Remarks |
|---|---|---|---|---|
| 1. Valsad | WCAH –1<br>WCAH-2, WCAH-2p | 120 | 124 | - |
| 2. Vadodara | WAG 5 | 100 | 91 | - |

Apart from the above there are 4 nos. of trip inspection sheds as given below.

Mumbai Central, BAMY (marshalling yard), Ratlam and Ahmedabad.

**Table 4-18 (B) Diesel Loco Sheds on WR**

| Location | Type of locomotives maintained at present | Capacity |
|---|---|---|
| 1. Ratlam | WDS4, WDM 2 | 100 |
| 2.Vadodara (for Ahmedabad) | WDH2, WDH 3A, WDS 4, WDS 4 | 100 |

2) NORTH WESTERN RAILWAY (Jaipur)

No Electric Loco Shed is there. Diesel Loco Sheds are shown in Table 4-19

**Table 4-19 Diesel Loco shed on NWR**

| Location | Type of locomotives maintained at present | Capacity |
|---|---|---|
| 1. Abu Road | WDM2, WDG3A, WDM3D, WDG 3A | 100 |

Workshop on NWR is in Ajmer for Carriage & Wagon workshop for both BG and MG.

Apart from the above the following workshops are available on Central Railway around Mumbai which also undertake POH, repair of locos and carriages of other Railways. Central Railway (HO-Mumbai, CST) does not fall in the dedicated route except for a small portion from J.N.Port to Vasai Jn.

Matunga -POH of BG coaches and Diesel Locos

Kurla -POH of Tank Wagons.

Bhusawal -Wagon repair workshop and POH of electric locos and an Electric Loco-shed for maintenance.

3) WEST CENTRAL RAILWAY (Jabalpur)

Loco sheds are shown in Table 4-20 (A) and (B). Workshop on WCR is Kota for BG Wagon repair workshop.

**Table 4-20 (A) Electric Loco Sheds on WCR**

| Location | Type of locomotives maintained at present | Capacity | Present holding | Constrains/ Remarks |
|---|---|---|---|---|
| 1. Tuglakabad (Delhi) | WA G5, WA G7 | 100 | 134 | - |
| 2. Itarsi | WA G5, WA G7 HA, WAM4 (Carried) | 100 | 135 | - |
| 3. New Katni Jn | WA G5, WA G7 | 150 | 113 | - |

**Table 4-20 (B) Diesel Loco sheds on WCR**

| Location | Type of locomotives maintained at present | Capacity |
|---|---|---|
| 1. Itarsi | WDM2, WDM3A, WDS6 | 100 |
| 2. Katni | WDM 2, WDM 3A, WDG – 3A, WDG – 3C | 100 |

4) NORTHERN RAILWAY, (New Delhi)

Loco sheds on NR are shown in Table 4-21 (A) and (B). Workshops on NR are as under:

Charbagh – Diesel Loco P&A and other heavy repair works of NR and WR
Jagadhari – Carriage wagon workshop & Bridge workshop.

**Table 4-21 (A) Electric Loco Sheds on NR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| *Ghaziabad* | WAM4P, WAP1/1E, WAP4, WAP5, WAP7, WAP 5/5&6, WAG-5H6 | 120 | 117 | |
| *Ludhiana* | WAG5/5H6/5H6, WAG7, WAM4 | 50 | 92 | |

**Table 4-21 (B) Diesel Loco sheds on NR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Tuglakabad | WDM-2, WDP1, WDM3C, WDP3A, WDM3A | 100 | 160 | - |
| Sakurbasti | WDS4 | 80 | 87 | - |
| Ludhiana | WDM2, WDG3A, WDM3A, WDM3B, WDM3D, WDM3C | 140 | 160 | - |
| Lucknow | WDM20, WDM3A, WDC3A | 100 | 129 | - |

5) North Central Railway (Allahabad)

Loco sheds are shown in Table 4-22 (A) and (B). There is no Workshop for Electric & Diesel locos and carriage wagons in NCR.

**Table 4-22 (A) Electric Loco Sheds on NCR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Kanpur Central | WAP4, WAG7 | 120 | 146 | |
| Jhansi | WAP4, WAG5H0/HB, WAG7 | 100 | 136 | |

**Table 4-22 (B) Diesel Loco Sheds on NCR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Jhansi | WPM2, WDM3A | 100 | - | |
| Agra | WDS4 | 50 | - | |

6) Eastern Railway (Kolkata)

Loco sheds are shown in Table 4-23 (A) and (B). Workshops/Maintenance shops are as under:

Mughal Sarai – Wagon repair shop
Liluah – POH of Carriage & wagon
Jamalpur – BG Diesel workshop
Kanchrapara – POH of AC Locos (for Howrah, Santragachi, MGS ASN)
Bawangachi & Tikiapara – Passenger rake maintenance

**Table 4-23 (A) Electric Loco Sheds on ER**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Howrah | WAP4, WAP5, WAP7 | 100 | 73 | There is scope for further expansion. |
| Asansol | WAG5/5A/5H6/5HR1, WAP6 | 120 | 121 | No space for further expansion |

**Table 4-23 (B) Diesel Loco Sheds on ER**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Howrah | WDM2/2A/2B | 50 | - | |
| Andal | WDS6, WDM-2/2D | 100 | - | |
| Burdwan | WDG2, WDM6, WDM2/2D | 100 | - | |

7) EAST CENTRAL RAILWAY (Hajipur)

Loco sheds are shown in Table 4-24 (A) and (B). New Railway coach maintenance workshop at Harnaut near Patna is under Construction for a capacity of 500 coaches / year.

**Table 4-24 (A) Electric Loco Sheds on ECR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| MGS | WAP1, WAM4/4P, WAP-4, WAG7 | 120 | 142 | Expandable to capacity of 150 |
| Gomoh | WAG7, WAG9, WAP7 | 120 | 125 | - Do - |

**Table 4-24 (B) Diesel Loco Sheds on ECR**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Patratu | WDM 2/2B, WDM 3A | 100 | - | |
| Mughal Sarai | WDM 212A, WDM2B, WDM3A | 100 | - | |

8) SOUTH EASTERN RAILWAY (Gardenreach)

Loco sheds are shown in Table 4-25 (A) and (B). Workshops/maintenance shops are as under:

1. Kharagpur – Electric loco carriage and wagon repair workshop
2. Santragachi – Passenger Rake Maintenance

**Table 4-25 (A) Electric Loco Sheds on SER**

| Location | Type of locomotives maintained at present | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Tatanagar | | 110 | 158 | - |

| | | | | |
|---|---|---|---|---|
| Santragachi (for passenger locos) | WAP4 | 50 | 45 | - |
| BNDM | WAP | 100 | 140 | - |

**Table 4-25 (B) Diesel Loco Shed on SER**

| Location | Type | Capacity | Holding | Remarks |
|---|---|---|---|---|
| Bokaro Steel city | WDM2 | 100 | - | - |

### 4.7.3 Maintenance System for the Rolling Stock

The maintenance system introduced by Indian Railways is shown in Table 4-26 Different systems have been adopted depending on the different designs and operating conditions.

On electric locomotive, the maintenance cycle of AC traction equipment is longer than on DC traction equipment due to the differences in the design of the traction motors. The maintenance system should be adopted for use with newly developed locomotives using AC traction. However, at the present time it would be difficult to estimate the maintenance cost for DFC since specific information, such as the number of locomotives to be maintained, is not available.

**Table 4-26 Maintenance System for Rolling Stock (Freight Use Only)**

| Inspection/Overhaul | Electric Locomotives | Diesel Locomotives* | Wagons |
|---|---|---|---|
| IA | 45 days | 45 days | |
| IB | 90 days | | |
| IC | 135 days | | |
| AOH | 18 months | 12 months | |
| IOH or ROH | 4.5 years or 600,000 km | | 18 months |
| POH | 9 years or 1,200,000 km | 4 years | 4.5 years |
| MTR | 18 years | | |

IA: Inspection A, IB: Inspection B, IC: Inspection C
AOH: Additional Overhaul, IOH: Intermediate Overhaul, ROH: Routine Overhaul, POH: Periodical Overhaul
MTR: Mid-term Rehabilitation
* Maintenance system for ALCO locomotive

### 4.7.4 The Present State of Locomotive Industry in India

There are two main locomotive builders, one railway factory and two coach factories under control of MOR. Their budget and production planning are controlled by MOR. And there are one heavy electric supplier and several wagon builders in India. Wagon builders are established by private capital. They supply their products to Indian Railways and other railways.

The following facilities were chosen for visiting in order to research their performance, capabilities and quality control systems: Chittaranjan Locomotive Works (CLW), an electric locomotive builder in Chittaranjan; Diesel Locomotive Works (DLW), a diesel locomotive builder in Varanasi; Railway Wheel Factory (RWF) in Bangalore; Bharat Heavy Electrical (BHEL), an electric equipment supplier in Jhansi, Bhopal and Bangalore; and Knorr-Bremse India (KBI), a brake system supplier in Delhi. The study team made visits to these companies.

The three companies' brief is outlined below as shown in Table 4-27. Knorr Bremse India is a 100 % German capital enterprise. It supplies air brake system and parts to Indian Railways. Sales from its railway business reached Rs. 15 billion for the year 2004-05.

The performance and capacity of these companies meets the requirements for Indian Railways for both the present and near future. These companies are running their quality control system according to ISO 9000 and have obtained ISO 14000 certification. The education and training system found in each company is well organised and contributes to ongoing improvement.

**Table 4-27 Outline Locomotive Builders and Equipment Supplier**

| | CLW * | DLW ** | BHEL |
|---|---|---|---|
| Established | 1947 | 1961 | 1962 |
| Annual Sales | Rs.835 Crores | Rs.964 Crores | Rs.10,336 Crores |
| Annual Production | Electric Locos: 90<br>Traction Motors: 474<br>Cast Steel: 2,071 tonnes | Diesel Locos: 148 | Diesel Locos: 5<br>Traction Motors: 2,185<br>Transformers for locomotive: 22 *** |
| Cumulative Production of Locomotives since Establishment | Steam Locos: 2,351<br>Diesel Locos: 842<br>Electric Locos: 3,251 | Diesel Locos: 4,899 | Diesel Locos: 179<br>Electric Locos: 160 |
| Number of Employees | 13,698 | 6,158 | About 1,300 in Jhansi,<br>About 800 in Bhopal |
| Total area | 18.32 $km^2$ | 89.00 $km^2$ | |
| Floor area in shops | 27,384 $m^2$ | 91,765 $m^2$ | |
| Others | ISO-9001, 9002 and 14001 certified | ISO-9001, 14001 and OHSAS-18001 certified | ISO-9001, 14001 and OHSAS-18001 certified |

* Data in 2004-05
** Data in 2005-06
*** Picked up only locomotives excluded power transformers and others

CLW manufactures and assembles electric locomotives including the body, bogie and traction motor. It can currently produce five different locomotives in parallel. The latest type in production is the WAG-9 6,000 hp with three phase asynchronous motor technology. The technology was introduced by ABB. Japanese technology has also been introduced for relatively old types of locomotives, such as those using DC traction motors. Transformer, electric equipment and traction motor components are supplied by BHEL in India. Some materials, such as insulation, are imported from Europe and Japan.

DLW manufactures and assembles diesel electric locomotives including the body, bogie and engine. It produces ALCO and GM locomotives in parallel. The latest type GM locomotive is a 4,000 hp unit with AC traction motor technology. The technology was introduced by General Motors and electrical equipment is supplied by BHEL.

RWF situated at Bangalore had started its production from 1987 by introducing casting steel wheel technology, forging axle technology and production facilities with technical know-how from the United States. Its employee strength is 2,500 persons. It produced 1,200,000 wheels in year 2005-06 and has plans to increase productive capacity up to 2 million wheels in few years. A new factory building is under construction to be opened in 2008. Earlier it exported wheels and axles to the United States, Myanmar, Bangladesh, etc. However, it had to change its policy to supply to IR only, without exporting, after domestic demand increased.

BHEL is the largest heavy electric equipment supplier for power plants and industries. It also supplies transformers, traction motors, equipment and driving gears to locomotive builders. Jhansi Factory builds locomotives and manufactures transformers. Bhopal Factory manufactures traction motors and gears. Bangalore based factory manufactures control equipment and semi-conductors. Its technologies were originally introduced by

ABB and Siemens of Europe, GE of the United States and Hitachi of Japan. BHEL has since acquired the technologies on its own in similar manner as the manufacturer's mentioned above.

Locomotives and wagons are built using stabilised technologies at the present. However it is hard to say if their performances are suitable for the requirements of DFC. However, Indian Railways, locomotive builders and suppliers all seem too keen to adopt new technologies for the project. There are possibilities to collaborate Japanese technology firms with Indian technology firms to produce the required performing equipments.

They are also interested to develop new locomotive technology, but the technical aspects for DFC have not yet been fixed, so it is difficult to make any headway towards further development at this point in time. As a full design change requires several years, it is desirable that the technical specification of the concerned equipment be fixed as soon as possible.

## 4.8 STUDY ON FEEDER ROUTES

### 4.8.1 Introduction

In the course of development of railway freight corridor, it is mandatory to develop/improve the feeder routes which connect the major origin/destination of cargo such as major ports and ICD's for container cargo, mineral mining, thermal power plants and iron & steel manufacturing plants for bulk cargo with DFC trunk lines to maximize the effectiveness of DFC. From this point of view, MOR has identified seven (7) routes for Western Corridor and seventeen (17) routes for Eastern Corridor as feeder routes of DFC in their letter No. 2005/PL/6/7 Pt.II. (refer next section for detail)

The objective of the study on the feeder routes in this JICA study is to review them from the view point of future cargo traffic demand and line improvement cost for the axle load of twenty five (25) tons. The work flow on the study of feeder routes is shown below.

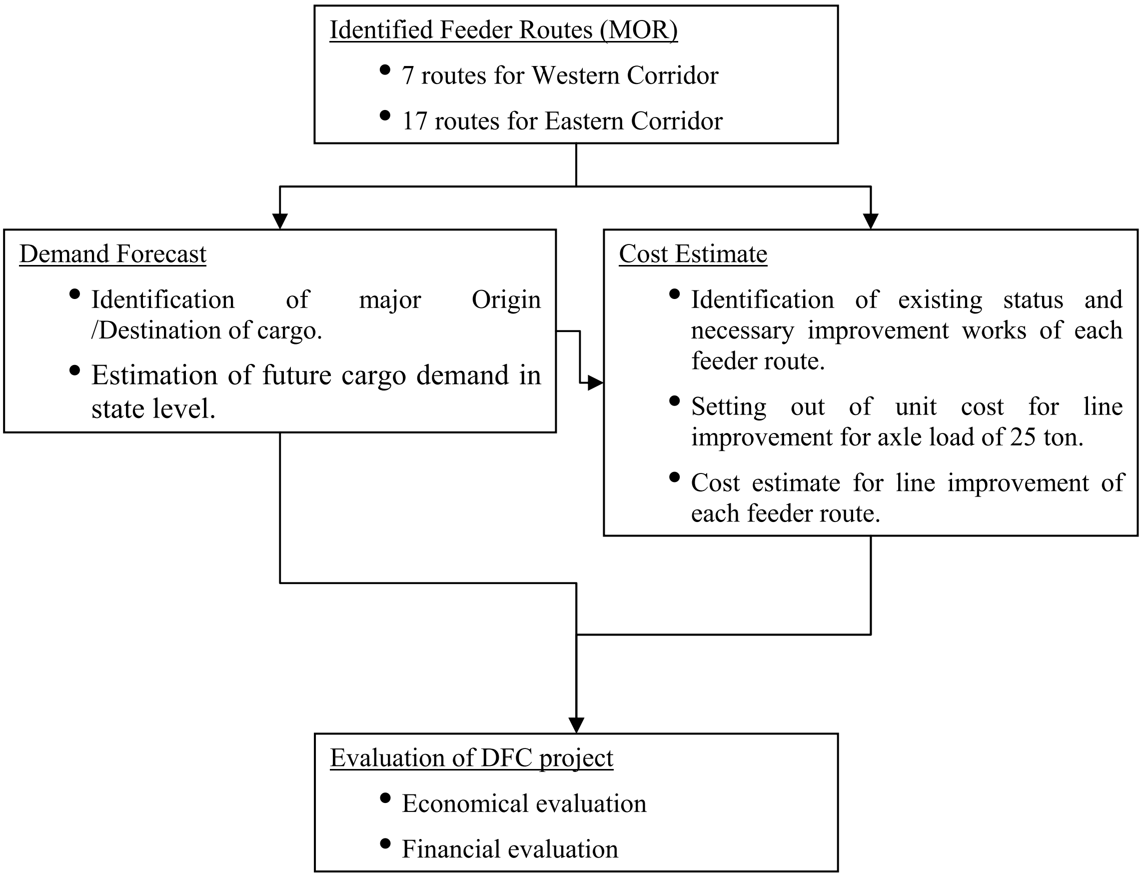



**Figure 4-16 Work Flow of the Study on Feeder Routes**

### 4.8.2 Identified Feeder Routes by MOR

Ministry of Railways announced to the concerned Zonal Railways, namely, Northern Railway, East Central Railway, South Eastern Railway, Central Railway, Western Railway, North Western Railway, North Central Railway and Eastern Railway, about the identified feeder routes for moving double stack container trains on Western Corridor and coal wagons for 25 ton axle load on Eastern Corridor in their letter dated on 4th April 2006. Seven (7) routes, totaling 1,379 km in length, and seventeen (17) routes, totaling 2,795 km in length are identified for Western and Eastern Corridor respectively as tabulated in Table 4-28, Table 4-29 and illustrated in Figure 4-16

**Table 4-28 Feeder Routes for Moving Double Stack Container Trains on Western Corridor Identified by MOR**

| No. | Origin | Destination | via | Length | Note |
|---|---|---|---|---|---|
| W1 | Pipavav | Mehsana | Surendranagar and Viramgam | 395 km | |
| W2 | Kandla Port | Palanpur | Gandhidham | 312 km | |
| W3 | Mundra | Gandhidham | | 66 km | |
| W4 | Viramgram | Samakhiali | | 182 km | |
| W5 | Hazira | Surat | | 40 km | |
| W6 | Ludhiana | Rewari | Hissar | 348 km | |
| W7 | Mumbai Port | Diva | Wadala and Kurla | 36 km | including connectivity with DFC |
| | | | Total Length | 1,379 km | |

**Table 4-29 Feeder Routes for Coal Wagons for 25tonne Axle Load on Eastern Corridor Identified by MOR**

| No. | Origin | Destination | via | Length | Note |
|---|---|---|---|---|---|
| E1 | Sonnagar | Barkakana | Garwa Road | 311 km | |
| E2 | Patratu | Gomoh | | 128 km | including PD Branch Line |
| E3 | Sonnagar | Gomoh | Gaya | 249 km | |
| E4 | Gomoh | Pradhankhunta | | 39 km | including Kusunda - Tetulmari (4.5km), Katrasgarh - Nichitpur, Pradhankhunta - Pathardih links (24km) |
| E5 | Pradhankhunta | Andal | Asansol | 75 km | including coal branch lines |
| E6 | Andal | Pakur | Sainthia | 151 km | |
| E7 | Chandrapura | Dhanbad | | 36 km | |
| E8 | Bhojudih | Gomoh | Mohuda | 44 km | |
| E9 | Aligarh | Harduaganj | | 15 km | |
| E10 | Kanpur | Paricha | | 198 km | |
| E11 | Mughalsarai | Unchahar | Janghai and Phaphamau | 205 km | |
| E12 | Varanasi | Rosa | Sultanpur and Utratia | 558 km | |
| E13 | Zafrabad | Tanda | | 99 km | |
| E14 | Ludhiana | Govindwal Sahib | Beas | 112 km | |
| E15 | Rajpura | Bhatinda (Lehra Mohabbat) | Dhuri | 173 km | |
| E16 | Sirhind | Nangal Dam | Rupnagar | 104 km | |
| E17 | Hissar | Suratgarh | Bhatinda | 298 km | |
| | | | Total Length | 2,795 km | |

### 4.8.3 Existing Railway System and Major Commodities of the Feeder Routes

#### (1) Railway System

Number of existing tracks and traction system (electrified/diesel) of the planned DFC trunk routes and identified feeder routes are illustrated in the Figure 4-17. The most part of feeder routes spreading out from the east end of Eastern DFC trunk route have electrified with double or more tracks. On the other hand, the feeder routes in the Gujarat area are all non-electrified single track. In selecting the railway system of DFC trunk routes, the inter-operability with these feeder routes has to be carefully considered.

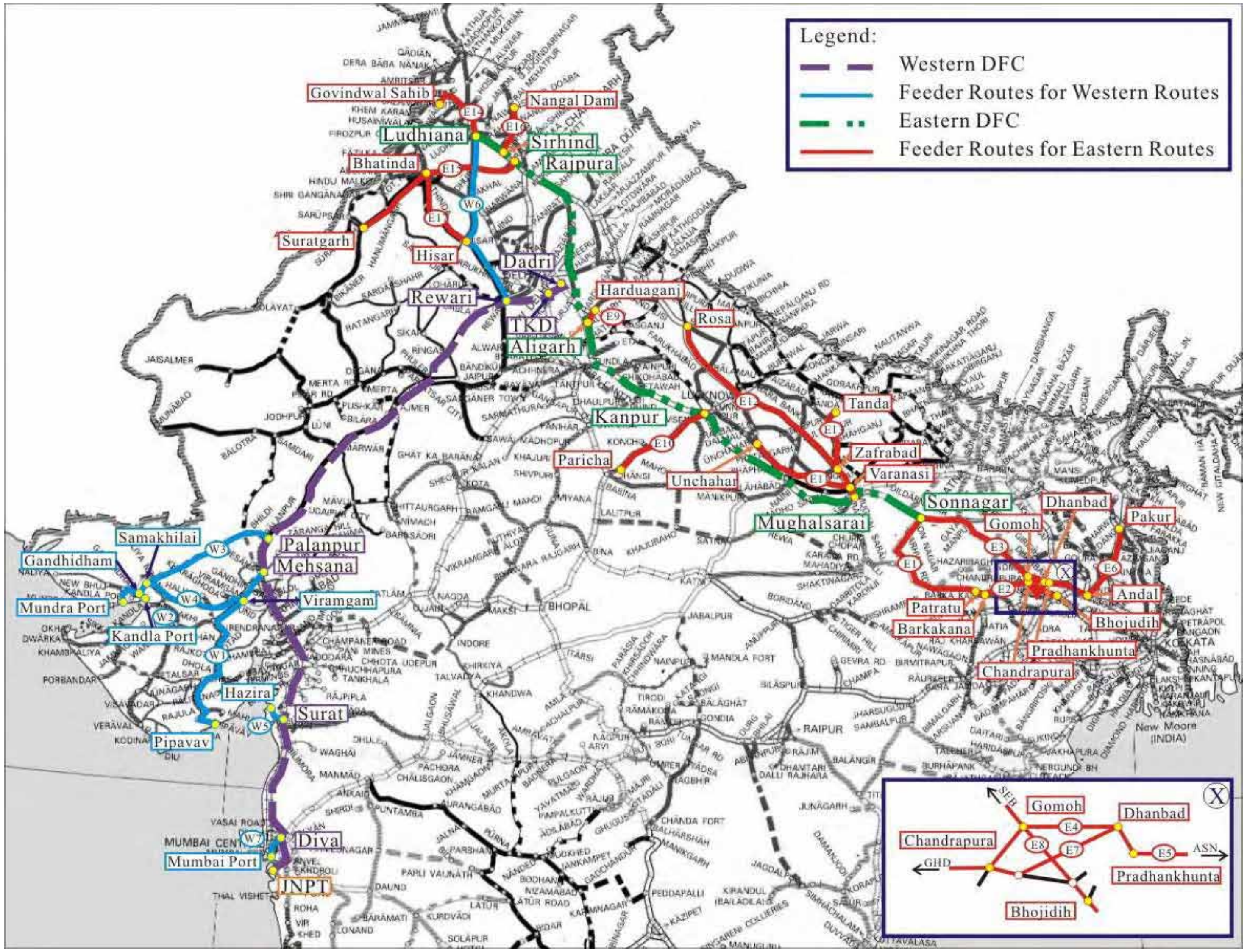



Figure 4-17 Feeder Routes Identified by MOR

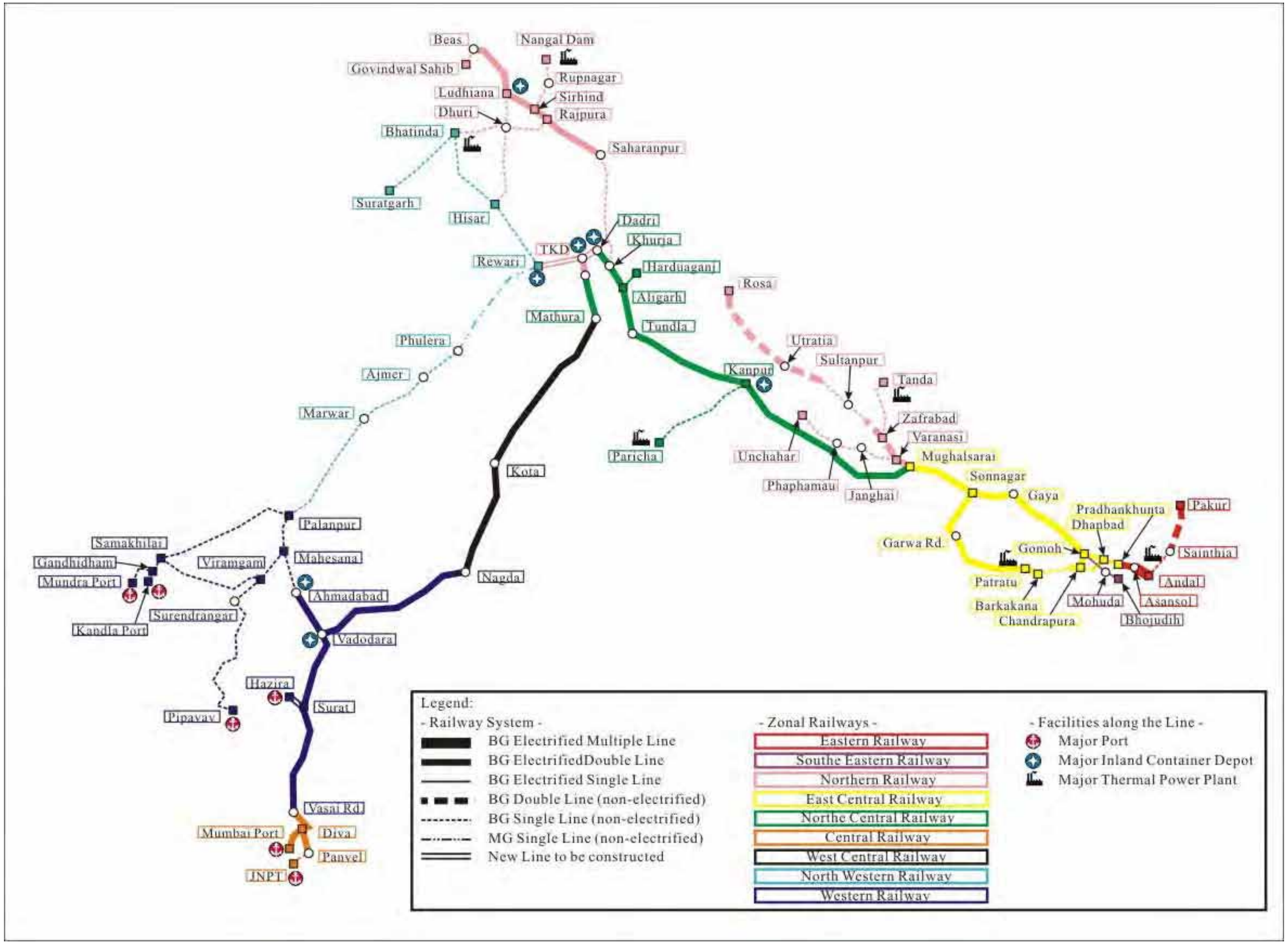



**Figure 4-18 Existing Railway System of DFC Trunk Routes and Feeder Routes**

### (2) Major Commodities

Table 4-30 shows the major commodities handled at the terminal station and its siding stations (Port, ICD, Colliery yard, Power station and etc.) of each feeder routes in the fiscal year 2005-06. It is noted that trains which don't have origin/destination at the terminal stations of feeder routes and its siding stations, were NOT included in this table.

The most major commodity departed/arrived from/to the terminal stations on the identified feeder routes of Western Corridor are containers. About two thousands container trains were operated from/to Ludhiana (Dhandarikalan ICD) (W6) in the whole year and Mundra (W3) followed by about twelve hundred. On the other hand, major items in Eastern Corridor are bulk cargo especially coal. More than four thousand trains each year of thermal coal have to be transported to the terminal stations and its siding power stations in Eastern Feeder routes.

**Table 4-30 Major Commodities Handled at Terminal Stations of Feeder Routes (2005/2006)**

| Route No. | Terminal Station | Major Commodities (number of trains per annual) | |
|---|---|---|---|
| | | As Origin Station | As Destination Station |
| Western Corridor | | | |
| W1 | Pipavav | Container (356) | Container (358) |
| W2 | Kandla | Imported Fertilizer (300) | De-oiled Cakes (123) |
| W3 | Mundla | Container (614),<br>Imported Fertilizer (495) and<br>Power House Coal (390) | Container (626) |
| W4 | Virangam / Samakhiali | N/A | N/A |
| W5 | Hazira | N/A | N/A |
| W6 | Ludhiana | Container (1011), Rice (65) and Wheat (45) | **Container (949)**, Coal (158) and Fertilizer (126) |
| W7 | Mumbai Port | Container (126) | Cement (398) and<br>Container (234) |
| Eastern Corridor | | | |
| E1 | Barkakana | Coal for Steel Plants (25) | Iron Ore (60) and<br>Manganese Ore (14) |
| E2 | Patratu | **Power House Coal (469)**, Fertilizer Coal (142) and<br>Public Coal (32) | Power House Coal (254) |
| E3 | Gomoh | N/A | N/A |
| E4 | Pradhankhunta / Kusunda / Katrasgarh / Pradhankhunta | **Power House Coal (349)**, Fertilizer Coal (276) and<br>Cement (271) | Ashes (73), Char Coal (73) and Iron & Steel (48) |
| E5 | Andal | Power House Coal (952), Steel (417) and Ashes (63) | Power House Coal (1123), Iron Ore for Steel Plants (822) and Coal for Steel Plants (386) |
| E6 | Pakur | Railway Material Consignment (492), Stone (432) and<br>Ballast (270) | N/A |
| E7 | Chandrapura / Dhanbad | N/A | Mixed (113), Wheat (43) and Petroleum Oil Lubricant (23) |
| E8 | Bhojudih | Coal for Steel Plants (188) | **Coal (399)**, Public Coal (145) and Power House Coal (57) |
| E9 | Harduaganj | N/A | N/A |
| E10 | Paricha | Cement (83) | Power House Coal (105) and Cement (19) |
| E11 | Unchahar | N/A | N/A |
| E12 | Rosa | Fertilizer (279), Wheat (74) and Rice (60) | N/A |
| E13 | Tanda | N/A | Power House Coal (589) |
| E14 | Goindwal Sahib | N/A | N/A |
| E15 | Bhatinda (Lehra Mohabbat) / Dhuri | Fertilizer (130), Cement (25) and Rice (15) | **Power House Coal (1041)**, Fertilizer Coal (206) and Low Sulphur Heavy Stock (79) |
| E16 | Rupnagar / Nangaldam | Cement (226) and Fertilizer (151) | Power House Coal (1616),<br>Coal (284) and<br>Fertilizer Coal (156) |
| E17 | Hissar / Suratgarh | Gypsum (25) and Container (13) | Furnace Oil (105), Fertilizer (57) and HSD Oil (46) |

Source: Centre for Railway Information Systems (CRIS)

## 4.9 PRESENT CONDITION AND FUTURE DEVELOPMENT PLAN OF TARGET PORTS

### 4.9.1 Present Condition of Target Ports

#### (1) Target ports for the Study

The following 7 target ports have been selected as the target ports for the Study to examine possible inter-modal transshipment of seaborne cargoes with inland transportation by the mode of railway.

- Maharashtra (Central Railway)
  1) Mumbai Port, 2) Jawaharlal Nehru Port;
- Gujarat (Western Railway)
  3) Gujarat Pipavav Port, 4) Kandla Port, 5) Mundra Port;
- West Bengal
  (Eastern Railway)
  6) Kolkata Dock System
  (South Eastern Railway)
  7) Haldia Dock Complex

#### (2) Share of cargo handling volume in the study ports

According to statistics data of the cargo handling volume from 1990 to 2004 at the major ports and container traffic of Indian ports, the top three ports are Visakhapatnam, Kandla and Chennai with a cargo handling volume of 47.7, 41.5 and 36.7 million tons respectively. Their combined cargo shipments in 2003-04 made up 36.4 % of the total for of all major ports in India. In the meantime, the share of cargo handling volume in 2003 – 2004 through the Study Ports namely, Kolkata, Haldia, Mumbai, J.N Port and Kandla was 2.5 %, 9.4 %, 8.7 %, 9.0 % and 12.0 % respectively, comprising 41.6 % of the total shipments in India. These facts underscore the importance of railway linkage to the Study Ports.

The share of container traffic of J.N. Port accounted for the greater potion of whole container traffic of Indian Ports and has reached 58.2 % in 2003-2004. The share of the other target ports has reached less than 5.1 % respectively.

### 4.9.2 Past Trend of Cargo Shipment

#### (1) Mumbai Port

The annual cargo handling volume during that period was between 25 million and 35 million tons. Though it had declined from 1996 to 2002 due to the shift of cargo from Mumbai Port to J.N. Port, it has been experiencing an upward trend since 2003, due primarily to the recovery of import cargo operations. It reached 35.2 million tons in 2004-2005. The import cargo has been experiencing an upward trend in recent years and has reached 23.1 million tons. On the other hand, the export cargo shows a relative stability, between 10 million and 15 million tons. The export cargo volume has been constant and was almost twice that of the import cargo volume in 2005. The major cargo is P.O.L (Petroleum, Oil and Lubricants) at Mumbai Port and it has increased gradually. Iron and steel is the second largest category of commodities, and it has also been increasing drastically.

#### (2) Jawaharlal Nehru Port (J.N. Port)

The cargo volume in 2004-2005 has reached 32.8 million tons and nearly twice as much as the cargo handled in 2000-2001. Both import and export cargoes have been showing slow upward trends. The containerized cargo reached 87.6% of all cargo in 2004-2005. Fertilizer (finished and raw) has decreased since 2002 because its domestic demand reportedly has declined.

### (3) Kolkata Dock System

The transit cargo handling reached 4.8 million tons or 48.1 % of all cargo handling volume in 2004-2005. The import and export cargo handling volume was between 2.7 and 3.4 million tons and between 0.9 and 1.7 million tons respectively and does not show remarkable inclination. The major import commodities, including transit cargo, in 2004-2005 are general cargo, timber, vegetable oil, pulses/peas and iron and steel; these cargo volumes are 969,000, 624,000, 528,000, 201,000 and 106,000 tons respectively. The major export commodities in 2004-2005 are general cargo, fly ash, jute and jute products, iron and steel and metal and metal products; their cargo volumes are 521,000, 324,000, 182,000, 173,000 and 39,000 tons, respectively.

### (4) Haldia Dock Complex

The annual import and export cargo handling volume has increased rapidly and has reached 25.0 million and 11.2 million tons respectively in 2004-2005. The import cargo handling volume is more than twice as much as the export cargo handled. The major import commodities in 2004-2005 were coking coal, liquid cargo, general cargo, LPG and fertilizer (raw materials); cargo handling volumes are 5.1, 1.2, 0.6, 0.5 and 0.4 million tons respectively. The major export commodities in 2004-2005 were iron ore, thermal coal, general cargo, iron and steel and liquid cargo; these cargo volumes are 5.4, 3.2, 0.8, 0.6 and 0.2 million tons, respectively.

### (5) Gujarat Pipavav Port

The annual cargo volume reached 13.1 million tons in 2005 - 2006. The major cargo is coal, steel coils and cement with volumes of 5.1, 2.6 and 2.1 million tons, respectively.

### (6) Kandla Port

The annual import and export cargo handling volume has increased little by little and reached 31.4 and 9.5 million tons respectively in 2004-2005. The import cargo volume is more than three times the export cargo volume.

The major import commodities in 2004-2005 are P.O.L, containerized cargo, fertilizer and coal; their cargo volumes are 22.1, 2.7, 0.7 and 0.2 million tons, respectively.

## 4.9.3 Past Trend of Container Traffic

The container traffic Mumbai Port has decreased since 1998 and has reached to 218,000 TEU in 2004-2005. The decreasing rate of container traffic in 2004-2005 is about 63 % in compared with 1997-1998.

The Jawaharlal Nehru Port handled 31.2 million ton of cargo during the fiscal year 2003-2004 which included 27.8 million ton (2.3 million TEU) of containerized cargo. The container cargo accounted for 88.8 % of the whole cargo handled at J.N. port. Out of the total container traffic of 2.3 million TEU handled at J.N. Port in 2003-2004, as much as 0.6 million TEU and 27 % moved to and from hinterland locations by railway.

The annual container volume of Kolkata Dock System, Haldia Dock Complex and Kandla Port was less than 200,000 TEU and they have increased little over the years.

The annual container traffic at Gujarat Pipavav Port in 2005 has reached to 272,096 TEU.

The annual container traffic at Mundra Port from April 2004 to March 2005 has reached to 220,321 TEU.

### 4.9.4 Present Condition of Port Facilities and its future plan

#### (1) Present condition of major port facilities

The features of major port facilities and cargo handling volume for target ports are summarized in Table 4-31and Table 4-32respectively.

**Table 4-31 Feature of Berth at Target Ports**

| Name of Port | Number of Berth | Depth of Berth | Maximum Length of Berth | Permit able Vessel (DWT) |
|---|---|---|---|---|
| Mumbai port | 51 | 6.1 – 10.0 m | 431 m (2 berths) | 16,000 |
| Jawaharlal Nehru port | 10 | 12.0 – 15.0 m | 712 m (3 berths) | 70,000 – 85,000 |
| Kolkata Dock System | 28 | 7.0 – 8.0 m | 172 m | <10,000 |
| Haldia Dock Complex | 12 | 8.5 m | 509 m (2 berths) | <10,000 |
| Gujarat Pipavav port | 4 | 12.5 m | 725 m (3 berths) | 45,000 |
| Kandla port | 11 | 11.2 – 14.6 m | 281 m | 75,000 |
| Mundra port | 4 | 10.0 – 15.0 m | 270 m | 90,000 |

**Table 4-32 Cargo Handling Volume and Container Traffic at Target Ports**

| Name of Port | Cargo Handling Volume (1,000 ton) 2003-04 | Container Traffic (1,000 TEU) 2003-04 |
|---|---|---|
| Mumbai port | 29,995 | 197 |
| Jawaharlal Nehru port | 31,190 | 2,269 |
| Kolkata Dock System | 8,693 | 123 |
| Haldia Dock Complex | 32,567 | 137 |
| Gujarat Pipavav port | 13,085 | 272 |
| Kandla port | 41,523 | 170 |
| Mundra port | - | 220 |

#### (2) Present container cargo handling productivity of target ports

Table 4-33 shows the current port facilities and cargo handling equipment each target port and Table 4-34 shows the container cargo handling productivity of target ports. The present productivity of target ports that was reported by each port is summed up at about 5.9 million TEU: about 3.8 million TEU at Maharashtra, about 0.3 million at West Bengal and about 1.8 million TEU at Gujarat. However, the present container traffic of Haldia and Kandla are assumed at the current value of container cargo handling productivity since their estimated productivities were not obtained at the period of site survey.

**Table 4-33 Summary of Port Facilities and Cargo Handling Equipment for Container Cargo**

| Name of Port | Container Berth | | | Number of Gantry Crane or Mobile Harbor Crane | Capacity of Gantry Crane (Unit/hour) |
|---|---|---|---|---|---|
| | Length of Berth | Number of Berth | Depth of Berth | | |
| Mumbai port | 476 m | 2 | 10.5 m | 2 | 15-16 |
| Jawaharlal Nehru port | 1,992 m | JNPCT : 3<br>NSICT : 2<br>GTI : 3 | 12.0-13.5m | JNPCT : 8<br>NSICT : 8<br>GTI : 8 | JNPCT : 24-25<br>NSICT : 26-27<br>GTI : 32 |
| Kolkata Dock System | - | 2 | 7.0 – 8.0 m | 2 | 22-25 |
| Haldia Dock Complex | - | 3 | 8.5 m | 2 | 30 |
| Gujarat Pipavav port | 725 m | 2 | 12.5 m | 3 | 29 |
| Kandla port | 281 m | 2 | 11.2 – 14.6 m | - | - |
| Mundra port | 632 | 2 | 17.5 m | 6 | 30 |

**Table 4-34 Summary of Container Cargo Handling Productivity at Target Ports**

Unit : TEU

| | Maharashtra | | West Bengal | | Gujarat | | |
|---|---|---|---|---|---|---|---|
| | Mumbai | J.N. port | Kolkata | Haldia | Pipavav | Kandla | Mundra |
| Cargo Handling Productivity | 200,000 | 3,600,000 | 150,000 | 137,000 | 419,000 | 170,000 | 1,200,000 |
| Sub Total | 3,800,000 | | 287,000 | | 1,789,000 | | |
| Grand Total | 5,876,000 | | | | | | |

### 4.9.5 Railway and Port Operation

#### (1) Mumbai Port

Many sidings of port railway run inshore of the main berth facilities of Mumbai port, including Indira Dock, Prince's Dock, Victoria Dock and Ballard Pier. The trains running at the rail-sidings are marshaled at the Wadala sidings.

The average number of trains from the port has decreased to 4 trains per day at the present time, compared to 6 trains per day in 1998. The number of trains from the port to Delhi is about one every 2 months. The train is composed of 45 wagons for container cargo, 40 wagons for open wagons for general cargo and 58 wagons for coal.

#### (2) Jawaharlar Nehru Port

1) Railway Yard (Port ICD)

Two container terminals are in operation in J. N. port, namely JNPCT and NSICT, and one more terminal named "Gateway Terminal" is now ready for operation. For the railway transfer of container cargo, a port railway yard called the port ICD is operating about 2 km away from the container terminals. The port ICD has five tracks. Line No. 1 and 2 are used by JNPCT, while line No.4 and No. 5 are assigned to NSICT. Line No. 3 located in-between the JNPCT and NSICT Terminals serves as a common engine run-round line.

2) Railway Yard Operation by CONCOR

The container is transported from the container terminal to the port ICD by tractor-trailer. There are two methods of handling the container cargo after sorting at container terminals, one is transportation and stacking at the port ICD and the other is transportation to the railway directly. Each train is composed of 45 wagons (5 wagon unit x 9); the length of each a unit is 69 m. The capacity of the train is 90 TEU. The monthly cargo transportation by train is approximately 70,000 TEU. The following shows transportation by import and export and the number of trains in June, 2006 is shown. This is based on information from CONCOR.

3) Connection with IR trunk line

Tracks for loading/unloading containers link between port ICD and the yard connects with Jasai yard of IR, which is located out of the port area on Panvel-Uran line. The construction of double tracking between port ICD and Panvel Jn. has been completed. IR lines beyond Jasai Yard have already been electrified.

### (3) Kolkata Dock System

There are 10 sidings at marshaling yard of Kolkata Dock System. The capacity of yard is sufficient at the present time. In addition, there are 3 sidings at container terminal behind Berth No.8.

The flow of container cargo from berth to freight train to station is 1) unloading from vessel by mobile harbor crane, 2) movement from apron to container yard by tractor/chassis, 3) unloading from tractor/chassis by reach stacker, 4) loading to tractor/chassis by reach stacker and 5) loading from tractor/chassis to wagon by reach stacker. Average loading time of the container cargo to a train takes for about 2 hours.

The container cargo from/to Kolkata Dock System is handled by about 70 % road and about 30 % railway. It is expected that the share of the transportation mode is converted in consideration of confirmed traffic congestion in and around Kolkata Dock System. Tractor trailer traffic is prohibited in the city between 8:00 and 20:00 so these trucks make a long line in and around Kolkata Dock System as they wait for the time to leave.

### (4) Haldia Dock Complex

Many sidings are located near the Haldia Dock Complex. Most are concentrated on the western part of the dock for handling bulk cargo, including coal, iron ore, limestone, coking coal, and others. The railway yard consists of a general marshalling yard and bulk handling yard, where departure and arrival operations for massive amounts of bulk cargo trains are executed. The port railway is connected to Durgachak belong to Southeastern Railway.

The average loading time from bulk to wagon takes about 4 to 4.5 hours.

### (5) Gujarat Pipavav Port

Cargo handling is currently being done by pay loaders, crane and mobile harbor cranes, electric leveling luffing (ELL) cranes, reach stackers and conveyer belts for coal handling.

The double-stack transportation of containers has been operated between Pipapav port and Kanakpura since March 24, 2006. The record for the double stack-operation is shown below.

March: 1 train, April: 2 trains, May: 5 trains, June: 1 train, July: 5 trains

### (6) Kandla Port

Ships are unloaded and loaded by the cranes mounted on the ship and newly installed cranes at the port. Loading for rail transport is completely manual.

### (7) Mundra Port

The container terminal is capable of accommodating Super Post Panamax 8,000 TEU vessels. The terminal operates 24 hours a day, 365 days a year and has no tidal restrictions.

Cargo such as coal, food grain and fertilizer are handled by cranes and conveyor belts while liquid cargo is handled through pipe line. Containers are handled by reach stackers, tire mounted gantry crane (TMG) and railed mounted gantry crane (RMG).

For loading for rail transport, coal is loaded by pay loaders, bagged cargo is loaded manually and containers are loaded by TMGs and RMGs.

Double stack transportation has operated between Mundra port and Jaipur since July 2, 2006.

## 4.10 PRESENT CONDITION OF ROAD NETWORK

### 4.10.1 Present Condition of Road Network in India

Planning, development and maintenance of national highways in India are dealt with National Highways Authority of India under Department of Road Transport & Highways, Ministry of Shipping merged with Ministry of Road Transport in September 2004. And other roads (state highways, major district roads, rural roads and minor roads) are controlled by each state and local government.

The highway network in India is approximately 3.3 million km length in 2007 as shown in the following table;

**Table 4-35 Length of Roads by Category (April, 2007)**

| Road Category | Length (Km) | Ratio |
|---|---|---|
| Expressways | 200 | 0.006% |
| National Highways | 66,590 | 2.0% |
| State Highways | 131,899 | 4.0% |
| Major District Roads | 467,763 | 14.1% |
| Rural and Other Roads | 2,650,000 | 79.9% |
| Total | 3,316,452 | 100.0% |

Source：National Highways Authority of India HP
http://www.nhai.org/roadnetwork.htm

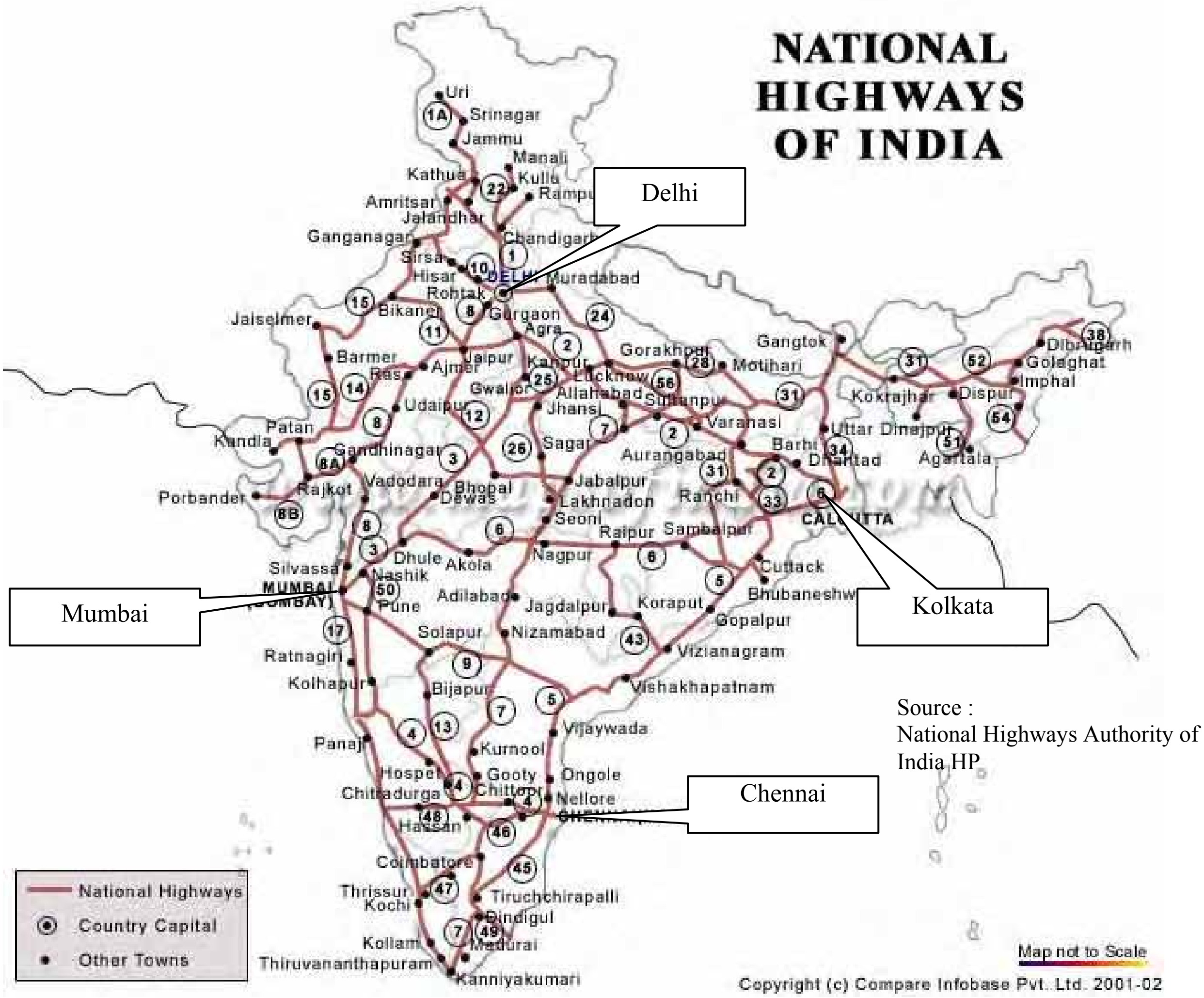



**Figure 4-19 National Highway Route Map in India**

Freight transport by road in India increased at an annual average growth rate of 10.16% in 1990s. The number of goods vehicles was 3.5 million in 2003 (as of 31st March) [2]. It increased at a CAGR of 8.2% in 1990s and a CAGR of 8.3% from 2000 to 2003.

About 65% of freight and 80% passenger traffic is carried by the roads. Number of vehicles has been growing at an average pace of 10.16% per annum over the last five years. "National Highways" account for only about 2% of the total length of roads, but carry about 40% of the total traffic across the length and breadth of the country.

Length of road by each lane number in India is shown in the following table. One or less lane-roads account for 32% of the total length of roads by July 2007.

[2] Ministry of Shipping, Road Transport & Highways

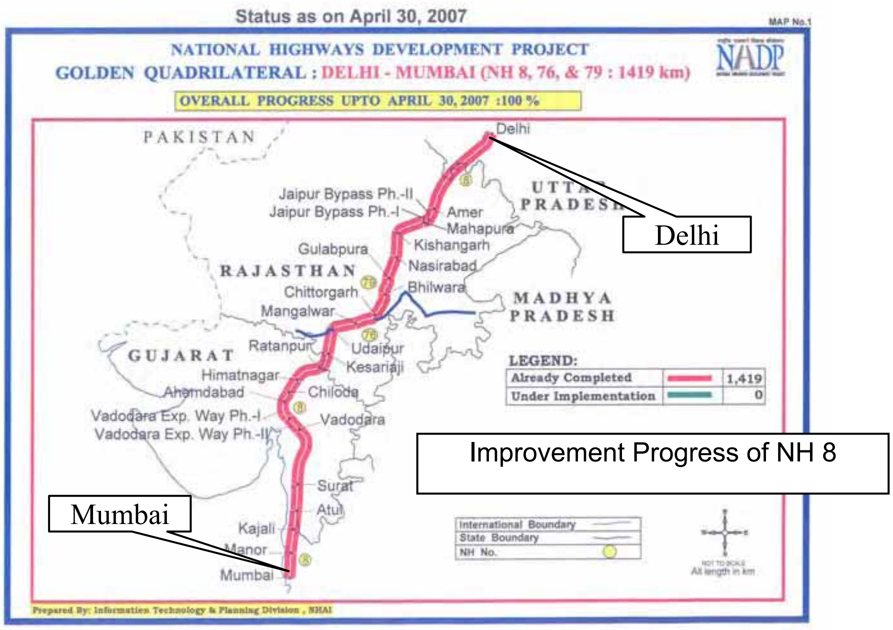
**Table 4-36 Length of Roads by Lane Number (July, 2007)**

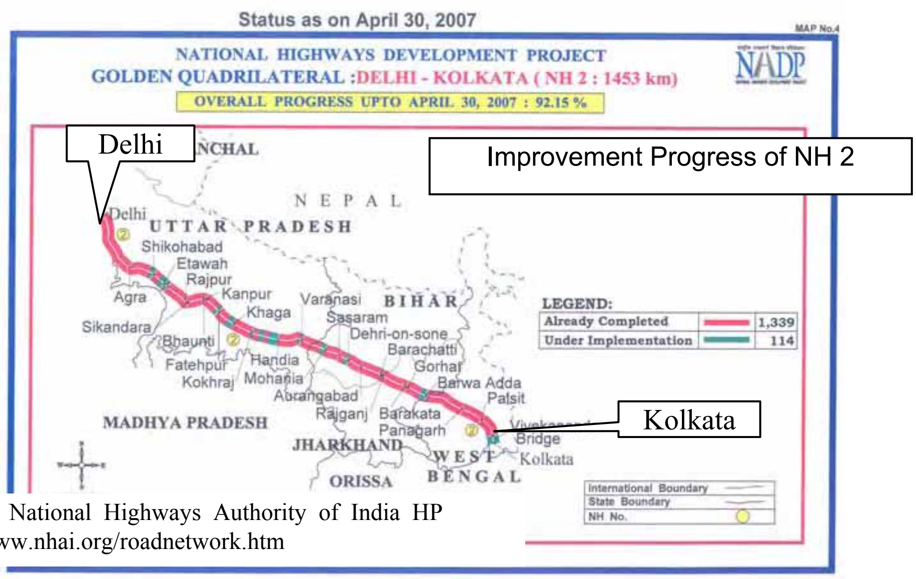
| Lane Number | Length (Km) | Ratio |
|---|---|---|
| Four or more Lanes | 400,000 | 12% |
| Double Lane | 1,860,000 | 56% |
| Single Lane/Intermediate Lane | 1,060,000 | 32% |

Source：National Highways Authority of India HP
http://www.nhai.org/roadnetwork.htm

### 4.10.2 Present National Road Conditions along the DFCs

National highways No.8 (NH8) paralleled with Western DFC and National Highway No.2 (NH2) paralleled with Eastern DFC are one of the most important routes as the Golden Quadrilateral Connection Highway. The exiting road condition of these routes is shown in the following figure.




Source: National Highways Authority of India HP
http://www.nhai.org/roadnetwork.htm

**Figure 4-20 Present Road Condition of NH8 and NH2**

The whole section in NH8 has been upgraded to 4-lane widening. In addition, the 4-lane expressway between Mumbai and Ahmedabad and 6/8-lane expressway between Delhi and Gurgaon is under construction currently. On the other hand, new bypasses and new ring roads around principal cities are due to be constructed based on a future traffic condition and development plan in the future.

92% section in NH2 has been improved to 4-lane widening at present. Meanwhile, there is the plan of new bypasses and new ring roads around principal cities are due to be constructed based on a future traffic condition and development plan in the future.

The plan of expressway network is not announced officially at this time, but expressways are constructed by BOT under state government.

## 4.11 INLAND CONTAINER DEPOT (ICD)

### 4.11.1 Function of ICD

ICD is one of bases of distribution facility and it has the following functions.

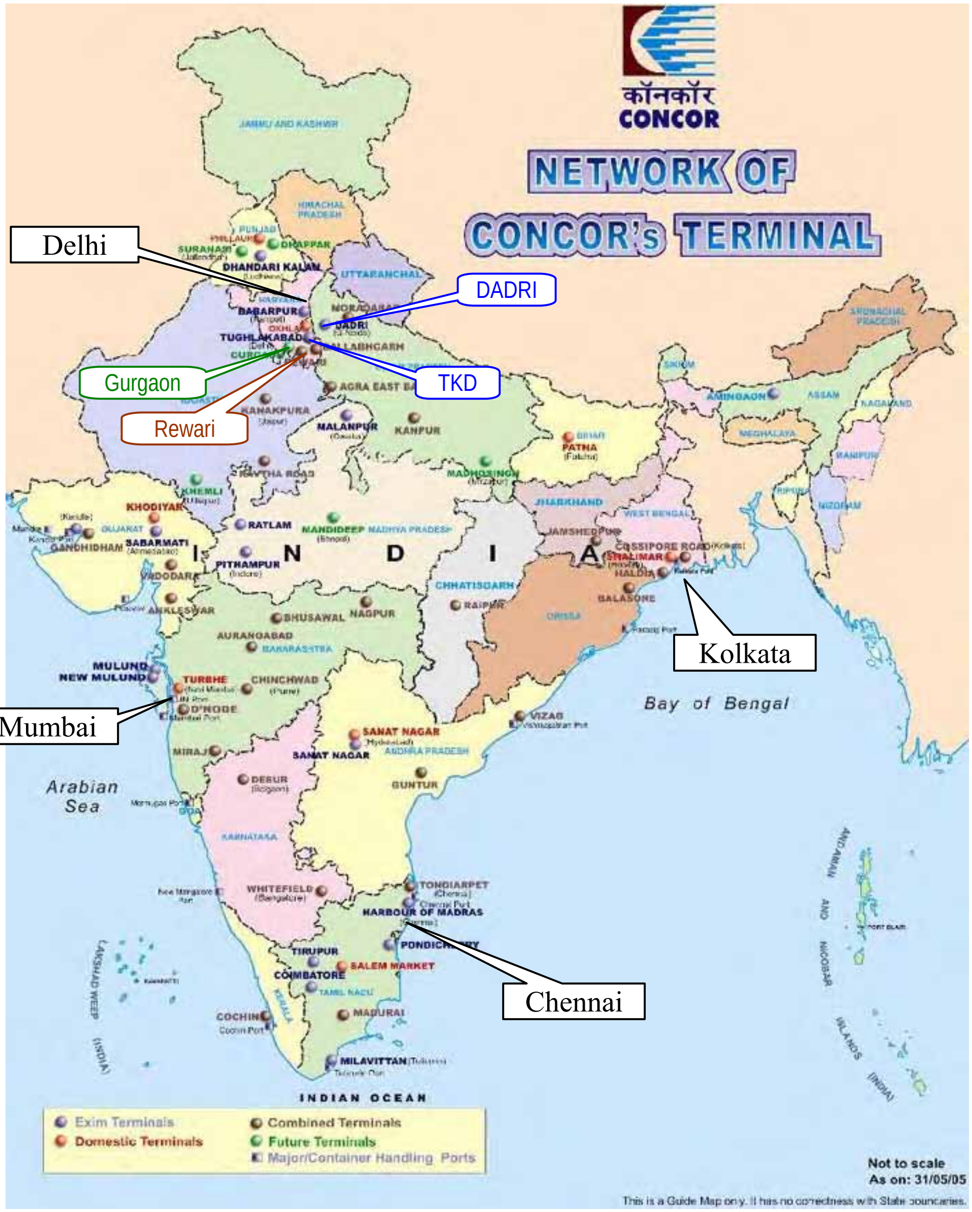
- to pass custom clearance;
- to issue the invoice for cargos between port and ICD and to set freight charges;
- to unload and load containers;
- to operate freight transport from/to ports;
- to transport containers by trailers between ICD and small scale of ICD or CFS (Container Freight Station);
- to operate empty containers; and
- to maintain and clean containers

### 4.11.2 ICD for CONCOR

CONCOR that was established in 1993 has 49 ICD as shown in Table 4-34 at the present time. Moreover, they have a development plan for 7 new ICD.

**Table 4-37 Summary of ICD for CONCOR**

| Description | Number of ICD | Name of Place |
|---|---|---|
| ICD for railway transportation that does not belong to CFS | 34<br>9 (Marked *) of the 34 ICDs have function of domestic container handling. | Dadri (G.Noida), Tuglakabad (Delhi), Jodhpur*, Moradabad*, Agra*, Kanpur*, Dhandari Kalan (Ludhiana), Jaipur*, Sabarmati (Ahmedbad), Vadodara*, New Mulund (Mumbai), Miraj*, Dronagiri Node*, Chinchwad (Pune)*, Amingaon (Guwahati), Cossipore Road (Kolkata), White field (Bangalore)*, Coimbatore Tondiarpet (Chennai)*, Madurai*, Sanatnagar (Hyderabad), Raipur (M.P)*, Tiruppur,Guntur*, Desur,Rewari, Balasore*, Jamshedpur*, Nagpur*, Daulatabad (Aurangabad), Milavittan (Tuticorin), Bhusawal* Malanpur (Gwalior), Rawtha Road (Kota) |
| Container Station for domestic containers | 8 | Phillaur (Ludhiana), Salem Market, Khodiyar (Ahmedabad), Turbhe (Mumbai), Fatuha (Patna), Sanathnnagar, Shalimar |
| ICD for road that is belong to CFS | 4 | Pithampur (Indore), Mulund (Mumbai), Pondicherry, Babarpur (Panipat) |
| ICD for road that is not belong to CFS | 3 | Ratlam, Ballabhgarh, Cochin |
| Future development plan | 7 | Bhopal (Mandideep)*, Dhappar (Chandigarh)*, Madhosingh (U.P.), Suranasi,Kolkata Port, Khemli |




Source：Container Corporation of India Ltd. (CONCOR) HP
http://www.concorindia.com/map.asp

Source：Container Corporation of India Ltd. (CONCOR) HP
http://www.concorindia.com/map.asp

**Figure 4-21 Location Map of CONCOR's Terminal**

### 4.11.3 Summary of Existing ICD Conditions around South Area in NCR

#### (1) Summary of TKD and Dadri ICD

CONCOR has 2 major ICD in the Delhi area (the Metropolitan area) such as TKD and Dadri. These 2 ICD have handled container more than 50% of the whole container cargos in the Metropolitan area. Their main features are shown below and in Table 4-38

1) TKD handles more containers than its capacity. Dadri is located far from Delhi and its annual handling volume is in short on its capacity.

2) Road around TKD is so congested with trucks to TKD that the authority prohibits the traffic of the trucks in the commuter time zone.

3) Dadri has a lot of space to expand its capacity.

**Table 4-38 Features of TKD ICD and Dadri ICD**

| | TKD | Dadri |
|---|---|---|
| Place | 17 km Southeast from Delhi<br>The roads around TKD are so crowded that the authority restricts the traffic of trailer trucks to the time zone between 11-17 and 20-5. | 45 km east from Delhi |
| Area | 50ha | 110ha |
| Annual container cargo handling volume | 400,000 TEU (Nominal capacity; 250,000TEU) | 100,000TEU<br>(Current capacity; 500,000 TEU. Final capacity; 1,000,000 TEU) |
| Sidings | 4 lines | 4 lines (There is plan to add 3 lines) |
| Facilities | 6 CFS,<br>Bonded warehouse (240TEU)<br>Parking capacity for trailers: 300 | 4 CFS |

### (2) Gurgaon ICD

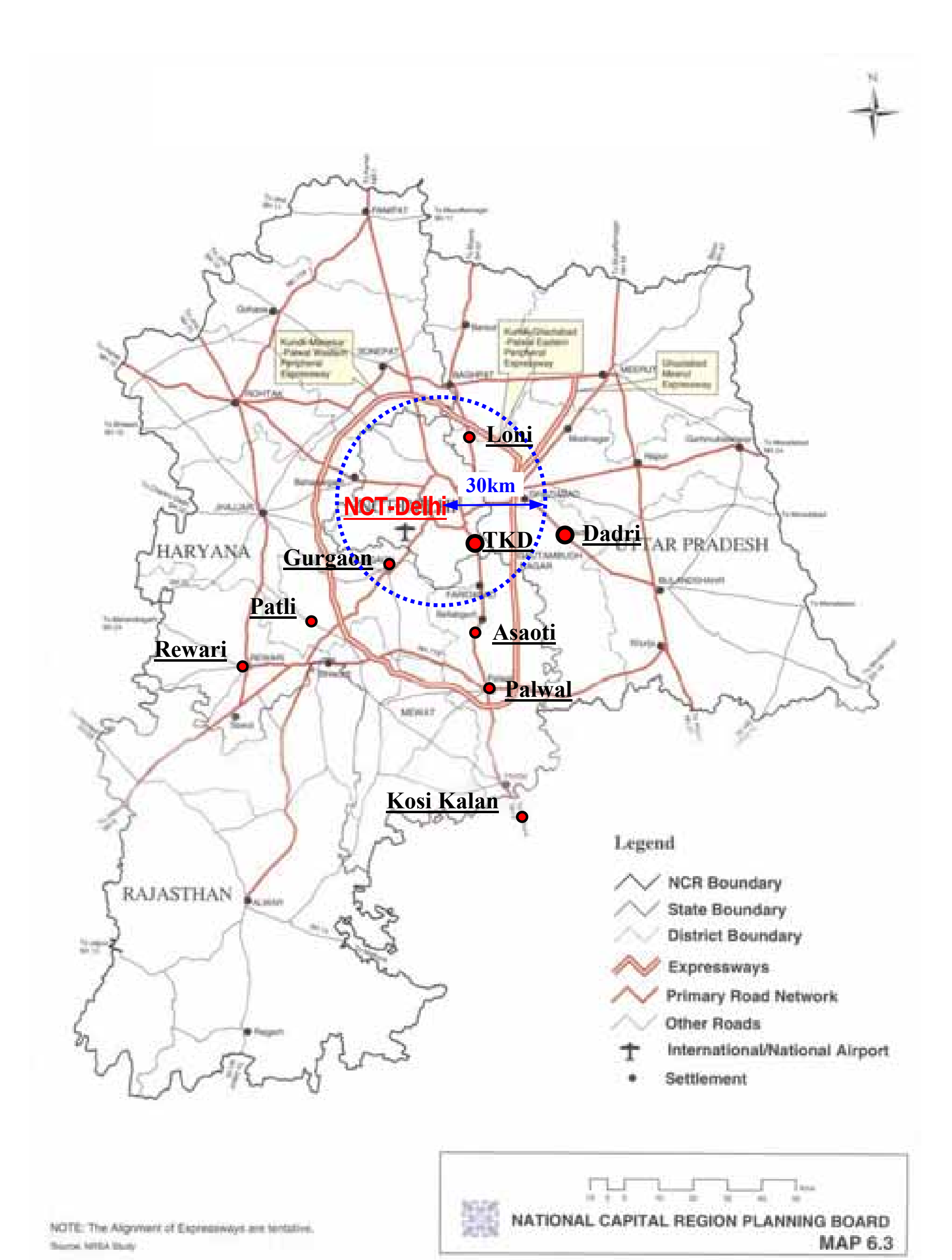
In the Gurgaon district, there is an ICD adjoining to Garhi Harsaru located about 35 km south-east of center of Delhi which is operated by Gateway Rail Freight Pvt. Ltd. in cooperation with CONCOR. However, the handling capacity of this ICD is quite limited. On the other hand, large factories including Maruti-Suzuki and Hero Honda are standing along the NH8 and the container traffic demand from/to these factories are growing larger and larger. At present, most of container traffic from/to these factories is transported by trucks and these trucks cause the heavy traffic jam on NH8 and around industrial zone.

### (3) Rewari ICD

Rewari Jn. located about 80 km south-east of center of Delhi has large scale of facilities as the junction station to Jaipur, Delhi and Hisar (Ludhiana) directions. However, in comparison with the station facilities, the urbanized area of Rewari city is limited to the southern area of railway station and a small number of factories is located in the controlled area now. Therefore, the container traffic demand as the origin / destination is smaller than Gurgaon.

## 4.11.4 Trend OF ICD BUSINESS

In National Central Region (NCR), there are two existing large-size ICDs at TKD and Dadri, and five medium and small-size ICDs at Loni, Asaoti, Palwal, Kosi Kalan, Rewari, and one ICD under construction at Patli. The total capacity of these existing ICDs is 1,400,000 TEUs per annum.




Base Map : REGIONAL PLAN-2021 NATIONAL CAPITAL REGION

**Figure 4-22 Location Map of ICD around NCR**

On the other hand, Indian Railways signed a concession agreement with 15 container train operators as shown in the following list in January 2007 that is expected to improve goods transportation and help rail freight revenues rise several fold. This signing heralds a new era in giving a legal shape to mutual relations, rights and responsibilities between the Indian Railways and the container train operators. These operators shall submit the future ICD plan to Indian Railway appropriately in accordance with this agreement, but there is no record that IR have received the plan from operators at this time. The Study Team has got information that future ICDs are planned at Bijwasan on the southside of International airport in Delhi, at Sonipat and Panipat on the north of Delhi NCR region, and at Patli on the south NCR Delhi region, from discussions held with CONCOR and Gateway Terminals India Pvt Ltd.

**Table 4-39 List of Operators to Sign the Concession Agreement with Indian Railway**

| Operator Name | License Fee |
|---|---|
| 1. Adani Logistics Ltd./Mundra Port & Economic Zone Ltd. (ALL/MPEZ) | Rs. 50 Crs. |
| 2. Boxtrans Logistics India Services Ltd. (BOXTRANS) | Rs. 10 Crs. |
| 3. Container Corp. Of India Ltd. (CONCOR) | Rs. 50 Crs. |
| 4. Central Warehousing Corporation (CWC) | Rs. 50 Crs. |
| 5. Container Rail Road Services (Pvt.) Ltd. (CRRS) | Rs. 50 Crs. |
| 6. Delhi Assam Roadways Corporation. Ltd. (DARCL) | Rs. 10 Crs. |
| 7. Emirates Trading Agency (ETA) | Rs. 50 Crs. |
| 8. Gateway Rail Freight Pvt. Ltd. (GRFL) | Rs. 50 Crs. |
| 9. Hind Terminals Pvt. Ltd./MSC | Rs. 50 Crs. |
| 10. India Infrastructure & Leasing Pvt. Ltd. (IIL) | Rs. 50 Crs. |
| 11. Innovative B2B Logistics Solutions (Pvt.) Ltd. (INLOGSTICS) | Rs. 10 Crs. |
| 12. Pipavav Railway Copn. Ltd. (PRCL) | Rs. 10 Crs. |
| 13. Reliance Infrastructure Engg. Pvt. Ltd. (RIEL) | Rs. 50 Crs. |
| 14. SICAL Logistics (SICAL) | Rs. 50 Crs. |
| 15. Krishak Bharati Cooperative Limited (KRIBHCO) | Rs. 50 Crs. |

# CHAPTER 5
# CURRENT IMPROVEMENT PLAN
# FOR EXISTING LINES AND FACILITIES

# CHAPTER 5 CURRENT IMPROVEMENT PLAN FOR EXISTING LINES AND FACILITIES

## 5.1 FUTURE RAILWAY NETWORK DEVELOPMENT PLAN

### 5.1.1 Initiatives taken by the Zonal Railways

During the past study period; the JICA study team (JST) visited associated Zonal Railways to collect data and information relevant to the Project. Respective Zonal railways have been implementing their railway improvement works mainly to trunk lines. Their improvement works are summarized as follows.

- Track improvement works: Improvement works mainly consist of replacement of 52 kg/m rails by 60 kg/m rails, replacement of existing sleeper by PC sleeper and improvement of ballast with 30cm thickness which are being implemented along trunk lines. (this specification of the improvement will meet the requirements under 25 ton axle load condition and can be considered to be equivalent to those for feeder lines of DFC)

- Reconstruction of bridges: Indian Railways (IR) have prolong history far beyond one hundred years and have a number of aging bridges including bridges crossing the River Ganga and other medium to small scale rivers. Zonal Railway's have been doing reconstruction of some of these aging bridges, including the Sone River Bridge between Sonnagar and Dehri-On-Sone, a 3,000 m long bridge. In principle generally, design axle load of 25 ton is applied for the reconstruction of the aging bridges.

- Double tracking and gauge conversion works; Delhi-Kota-Mumbai line and Delhi-Allahabad-Howrah line, which are the most important trunk lines in India, are fully equipped with double track system or more. However other trunk lines still have single track sections and respective Zonal Railway's have been implementing double tracking works for these sections. Zonal Railways have been converting meter gauge track to broad gauge, continuously.

- Modernization of signaling system; Improvement of signaling system with automatic block signaling system, which has been used only in urban railway system in India, is planned to be implemented in the sections between Ghaziabad and Kanpur.

- Particular track improvement works by South Eastern Railway; South Eastern Railway has been implementing track improvements to accommodate 25 ton axle load condition for coal transport in their territory. In this project, 30-ton of design axle load is applied to the bridges which are reconstructed due to the shortage of strength to take 25 ton axle load.

The above railway improvement projects have been implemented by each Zonal Railway individually and future improvement projects of respective Zonal Railways have not been fixed yet (or not yet confirmed). The railway modernization plan authorized by the Railway Board under the Ministry of Railway (MOR) is only "Integrated Railway Modernization Plan for 2005 to 2010 in November, 2004", which is introduced in the following section.

### 5.1.2 Improvement Plan

MOR announced its Integrated Railway Modernisation Plan for 2005 to 2010 in November, 2004. (This plan is hereinafter called as "IRMP")

The IRMP clearly indicates the aim of the MOR to modernize the Indian Railways network. In this section, the IRMP is introduced as the summary that is conscious of the portion relevant to the Dedicated Freight Corridors.

The IRMP expresses that in order to put India at its rightful place in the world; IR should provide a modern, world-class rail network.

The plan is divided into three categories: the Passenger Business Segment, the Freight Business Segment and one entitled as other Modernization Initiatives. The IRMP describes these three categories as follows;

1) Passenger Business Segment

   Passenger satisfaction is the main objective for the modernization of this segment. This includes steps such as providing high-speed trains, better information through the use of advanced information technology, and cleaner stations and coaches that are easier to use.

2) Freight Business Segment

   Coping with the increasing volume of freight is the main issue to be faced by the modernization measures. Here steps include developing new terminals, adopting modern rolling stock that includes new braking systems and providing a better information system.

3) Other Modernization Initiatives

   Supporting the business objectives of both freight and passenger services are the focus of this segment, particularly the modernization of fixed infrastructures. This includes the upgrading of tracks, bridges, signaling, telecommunications, rolling stock, safety, training and other information technology based systems.

According to information obtained from Zonal Railways about their improvement plans/works of existing lines which might be planned/implemented based on the Integrated Modernization Plan, almost all Zonal Railways are mainly concentrating on their feeder routes of DFC to meet the required track and structure strength, especially the requirement of 25 ton axle load.

Other investment items in the IRMP also indicate that the trend towards DFC preparation is the main feature, except for the Passenger Business Segment.

The contents and their anticipated costs shown in the IRMP have been abridged for the DFC Study and are introduced below.

### (1) Passenger Business Segment

The anticipated cost for the passenger business segment is Rs. 5,737 Cr. This segment is not directly related to the DFC project because the main object is passenger satisfaction. Rs.4,172 Cr of the total Rs.5,737 Cr is earmarked for introducing the latest technology for high-speed coach travel.

### (2) Freight Business Segment

This segment seems strongly directed at the DFC with a total anticipated cost of Rs. 5,213 cr. The contents can be divided into the following five categories.

1) Capacity enhancement

The target is the completion of 75 throughput enhancement works included under National Rail Vikas Yojana (NRVY), 68 ongoing sanctioned works and 7 other identified works. The total cost of these projects is Rs. 4,390 Cr.

2) Development of 40 modern freight terminals

In order to provide quicker loading/unloading of rakes along with improved turnaround and better customer satisfaction, these 40 modern freight terminals will include full length rake handling facilities, engine on-load working, adequate shunting necks, illumination for round the clock operations, weigh bridges, and others. The total cost is Rs. 120 Cr.

3) Modernization of freight operation and maintenance

This category includes: a Web-based claims management system, the extension of the freight operation system, the modernization of freight maintenance, the development of Railways door-to-door service, Locator for diesel locomotives and electric locomotives for identified sections and the introduction of self steering bogies. The total cost is Rs. 214 Cr.

4) Adoption of a new type of wagon and braking system

This category includes: the introduction of corrosion-resistant stainless steel body wagons, the introduction of lightweight aluminium wagons to increase carrying capacity, the modernization of the guard's brake-van and the provision of a bogie mounted brake system on freight stock to improve reliability and safety. The total cost is Rs.489 Cr.

5) Others

Other items, but no cost information, included in the IRMP is as follows: the operation of freight trains at 100 km/h on specified sections, the introduction of high axle load operations on selected routes, inclusion of public and private-owned warehouse facilities near rail terminals and the introduction of double stack containers on specified routes.

### (3) Other Modernization Initiatives

The anticipated cost for the other modernization initiatives is Rs. 12,995 Cr. The modernization initiatives other than those relating to freight and passenger business are primarily for the infrastructure to support the business objectives. The modernization of fixed infrastructures will be the major investment and will have to be planned in consideration of daily train operation. This segment is divided into seven categories in the IRMP as summarised below.

1) Track modernization

Track modernization is planned to be carried out as one of the major preparations for the DFC feeder routes in order to accommodate the heavier 25 ton axle loads. This will not only be implemented on DFC feeder routes, but will also apply to other lines including trunk lines with the aim of safely operating the trains at higher speeds. The total cost is Rs.3, 812 Cr. This track modernization consists of the following.

- The laying of a modern track using heavier 52/60 kg/m rails that have a higher ultimate tensile strength (UTS) of 90 kg/mm$^2$ and a low hydrogen content (1.6 ppm) using PRC sleepers and modern elastic fastenings.
- The introduction of arrangements to handle and transport the long rails using modern techniques.

- The introduction of a modern self propelled ultrasonic rail testing (SPURT) car.
- The introduction of mechanization for track maintenance and relaying activities.
- The introduction of mobile maintenance units (MMU) for track maintenance.
- The introduction of mobile flash butt welding equipment.
- The adoption of modern improved turn-outs with thick web switches (TWS) and weldable cast manganese steel (CMS) crossings.
- The confirmation of the safety on long welded rails through the utilization of modern stress measuring methods.
- The implementation of preventive rail grinding.
- The implementation of inspection and track monitoring through the use of modern equipment.

2) Bridge Modernization

Bridge modernization is mainly for testing, monitoring and maintenance; however the part of the bridge rehabilitation of old bridges may be one of preparatory works for DFC feeder routes. The total cost of bridge modernization is Rs.945 Cr., including the following items.

- The development of a modern comprehensive bridge management system for IR.
- The introduction of modern inspection techniques and adoption of developed techniques for bridges on Indian Railways.
- The arrangement of studies and projects for investigating the various modern technological developments that have been made in the area of bridges.

3) Modernization of signaling and telecommunication systems

The modernization of signaling and telecommunication systems is a very important issue for handling the present traffic with higher levels of safety and operational efficiency. The total cost is Rs. 3,543 Cr., which includes the following.

- Replacement of antiquated signaling assets with relay or solid state interlocking units that include data logging capabilities.
- Complete track circuiting at all block stations on A, B, C, D Special and E Special routes
- Train protection and warning systems (TPWS).
- Block proving using axle counters (BPAC).
- Anti-collision device (ACD) with signal passing at danger prevention feature.
- Continuous track circuiting.
- Computer-based centralized traffic control.
- Mobile train radio communication systems.
- Train management and information systems.
- Linking of remote V-SAT terminals to railway HUB for remote locations of FOIS, PRS, UTS and MIS.

4) Modernization of electrical systems

The total cost of the modernization of the electrical systems is Rs.1,870 Cr., and includes the following.

- The enhanced manufacture of three-phase locomotives at Chittaranjan Locomotive Works (CLW)
- The development of an Insulated Gate Bipolar Transistor (IGBT) based propulsion system for three-phase electric multiple units and electric locomotives.
- The provision of crew-friendly cabs on electric locomotives.
- The provision of additional simulators.

5) Modernization of mechanical management systems

The total cost of modernization of mechanical management systems is Rs.2,306 Cr., and includes the following items.

- The increased manufacture of high horsepower three-phase diesel locomotives.
- The provision of crew-friendly cabs for diesel locomotives.
- The provision of simulators for the training of drivers.

6) Modernization of disaster management capabilities

The rescue and relief services for use during train accidents needs to be upgraded to enable proper response to accidents, involving the faster and heavier trains. The total cost of modernization of disaster management is Rs.387 Cr. and includes the following.

- Self-propelled accident relief trains (SPART) with rescue and medical relief capability.
- Emergency rail-cum-road vehicles for accessing difficult areas.
- The establishment of the Institute of Rescue and Medical Relief at Bangalore.
- Emergency rescue vehicles for faster response by road.

7) Other initiatives

The total cost of other initiatives is Rs. 132 Cr. and includes the following.

- The organization of a technology mission on railway safety.
- The construction of a dedicated test track.
- The optimization of investment planning processes through long range decision support systems.
- The mapping of Indian Railway's network and assets and facilities using the Geographical Information System (GIS).
- The modernization of train costing system.

### 5.1.3 Ongoing and sanctioned existing line improvement projects

#### (1) Outline and main items of existing line improvement plan

1) Modernization of the Signaling System

a) The MOR plan for enhancing carrying capacities

Under the circumstances described above, the policies of the MOR carrying capacity enhancement plan are as follows.

- Introduction of automatic signaling system in which a blocked section is shortened to 1 km – 2 km (mainly 1km)
- Introduction of electronic interlocking device (SSI) and SIS-based CTC at some stations
- Improvement of level crossing (introduction of lights activated by movement at level crossing and combining the faculties of block signals)
- Introduction of Axle Counter or AFTC (AF track circuiting) for train detection

b) An example of signaling improvement

The following are implemented for automatic signaling in the signaling improvement project on the section Kanpur-Ghaziabad.

- Improvement of Solid State Interlocking

- Improvement of Main Signal 3 Aspect
- Improvement of Point Machine
- Improvement of Audio Frequency Track Circuit（Centre Fed）
- Improvement of Train Protection & Warning Devices
  - On board with CENELEC DMI (with one BTM antenna)
  - On board with simplified DMI (with one BTM antenna)

The above improvements are also planned to be conducted on other sections and MOR expects that the line capacity will be increase to around 100 trains/day after their implementation.

2) Telecommunication system arrangement plan

Telecommunication improvements include the following items.

- Introduction of Optical Fiber Cable
- Introduction of GSM- based (Global System for Mobile Communication) mobile telecommunication system
- Introduction of V-SAT（Very Small Aperture Terminal）in the remote areas where the telecommunication system has not been arranged
- Replacement of the analogue switch-board with digital switch-board and integration of 2MBPS interfaces for realization of seamless connectivity condition.

3) Doubling (track addition to the side of an existing line)

a) General sections of doubling

It has been planned to double the single-track lines and upgrade suburban commuter lines to have 3 to 6-tracks as in Delhi and other big cities

The following diagrams are shown Figure 5-1 and Figure 5-2 the general formations of a bank and a cut with a new track added to the side of an existing line.

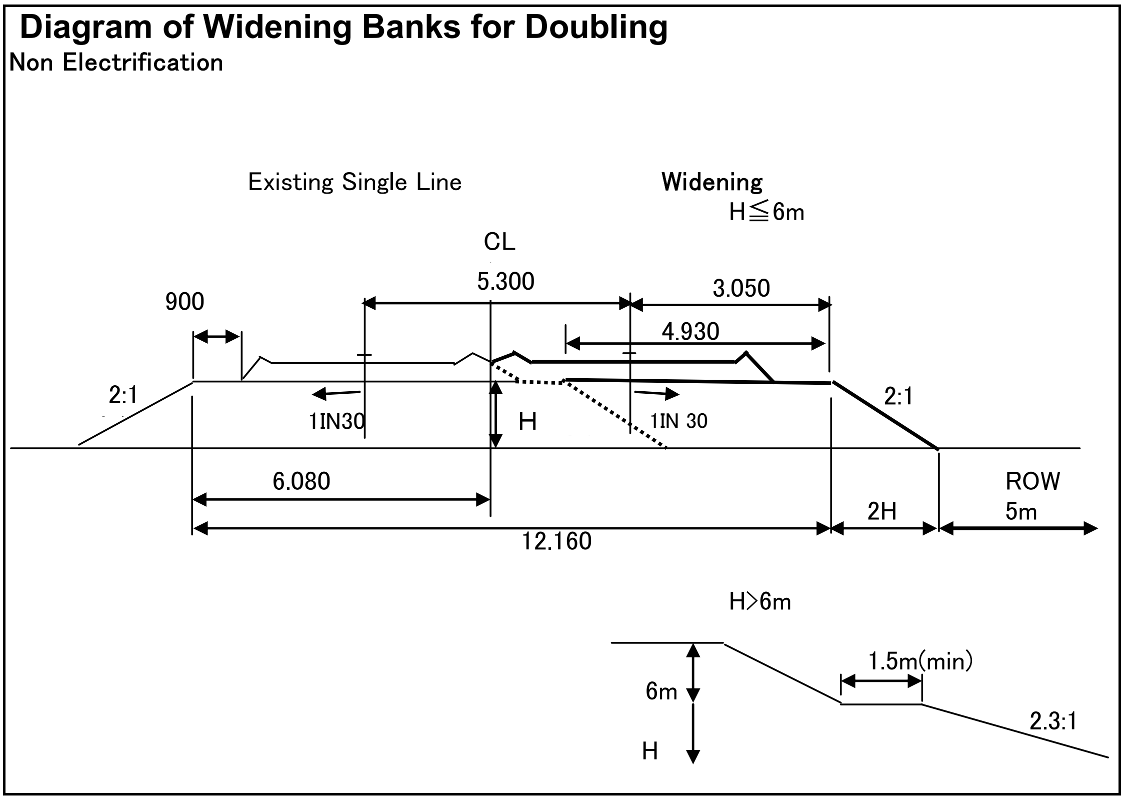



**Figure 5-1 Diagram of Widening Banks for Doubling**

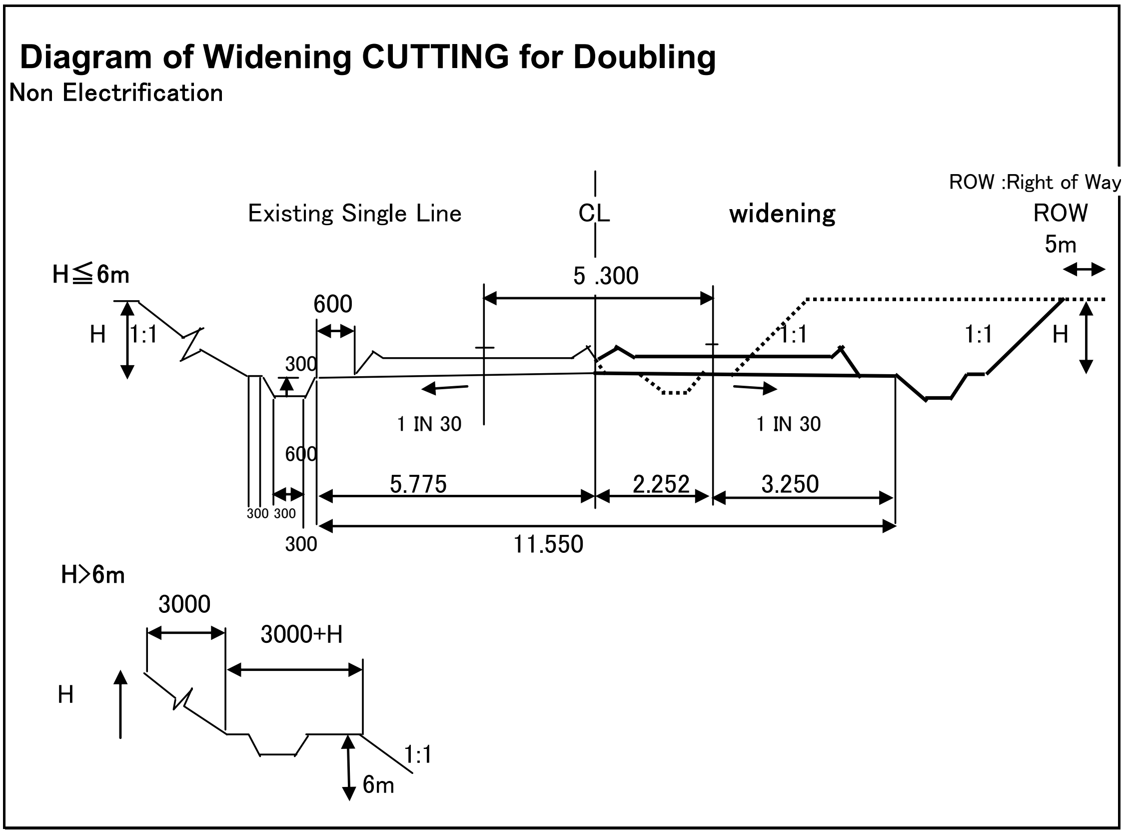



**Figure 5-2 Diagram of Widening Cutting for Doubling**

b) Existing line improvement plan

The single truck section and their lengths of existing line are shown in Table 5-1

**Table 5-1 Single-line Sections and Their Length**

| | Section | Length km |
|---|---|---|
| Eastern DFC | E1 route Khurja-Saharanpur | 207.4 |
| | E2 route Zafrabad-Utratia | 237.8 |
| Subtotal | E1route + E2route | 445.2 |
| Western DFC | W1 route | |
| | W2 route Ahmedabad-Jaipur-Dehli Cantt | 998.0 |
| Subtotal | W1route +W2route | 988.0 |
| Total | All existing single-track sections improved | 1,433.2 |

4) Station yard improvements

Improvement plans include the following.

a) To extend loop lines beyond the minimum length of 686 m

b) To increase the minimum length between a signal and point-tip to 13 m

Newly constructed turnouts for the above purposes are taken as improvement facilities.

5) Track improvements

Improvement plans include the following.

a) Conversion to 60 kg, 90 UTS, PSC-6, 1660/km

6) Bridge improvement

Improvement plans include the following.

a) New bridge construction for doubling

b) Old bridge replacement and strengthening

c) Elimination of level crossing by ROB (Road Over Bridge)

7) Conversion from meter gauge to broad gauge

### (2) Scope of Improvement

1) Scope of Improvement

Table 5-2 shows the scope of the MOR improvements in the years 2005-06 and 2006-07, mainly to the sections where signaling and station yard improvements are conducted to enhance the line capacity. The doubling works are also described for reference.

a) Signaling improvement

The signaling improvement works on the sections, Sonnagar-Khurja (821km) on E1 route (1,223 km) and Vasai Rd-Vadodara (344.1 km) and New Delhi- Palwal (53.7 km) on W1 route, have been completed, and on other sections the works are to be completed successively with the budget for the year 2006-07.

b) Station Yard Improvement

The main works are for loop addition on E1 and W1 routes.

c) Doubling

The doubling works are carried out on the sections, Zafrabad-Utratia (237.8km) on E2 route and Phulera-Jaipur-Bandikui (145.1km) on W2 route.

(The following table does not include works for multiplication to 3 to 5 tracks.)

**Table 5-2 Scope of Improvements on the Four Existing Routes**

| Item | E1 Route (1,223.0 km) | E2 Route (818.0 km) | W1 Route (1,460.9 km) | W2 Route (1,465.5km) |
|---|---|---|---|---|
| Signal Improve-ments km | Sonnagar-Khurja 821km | N.A | VasaiRd-Vadodara 344.1km<br>New Delhi- Palwa 53.7km | N.A |
| Station Yard Improve-ments | Allahabad Div. 5－Stn(Adll. Loops)<br>Mughal Sarai-Ghaziabad 4Stn.7Addi. loops | N.A | Nagda-Mathura Directional Loops 6<br>Virar-Surat Addl.Loops 6 | N.A |
| Doubling km | N.A | Zafrabad -Utratia 237.8km | N.A | Phulera-Jaipur -Bandikui 145.1km |

Source: MOR data, 2005-06 and 2006-07

1) Future improvement works in RITES Report

Table 5-3 shows the signal improvement works referred to in RITES Report and planned to be carried out in the near future.

**Table 5-3 Future Improvement Works in RITES Report**

| Facilities | Section | Length/ Station no. | Remarks |
|---|---|---|---|
| Blocking | Ghaziabad－Sonnagar | 883.4km | AF track circuiting |
| Electronic Interlocking | Khurja－Mughalsarai | 102 stations | Electronic Interlocking |
| Level Crossing | Khurja－Mughalsarai | 697.1km | Automating |
| Operation Control | Khurja－Kanpur | 40 stations | CTC |
| Blocking | Churchgate－Vadodara | 70.1 k m | DC track circuiting(Completed) |

Source: Existing Signaling State compiled from RITES Report

## 5.2 FUTURE PORT DEVELOPMENT PLAN

### 5.2.1 Future Port Development Plan

1) Mumbai Port

The Master Plan on container terminal development project for Mumbai Port was carried out by JICA study team (JST) in 1996. The study was reviewed by Consulting Engineer Services PVT. Ltd., a local consultant in 2005, since the study had already become outdated by almost 10 years. According to the study report, the main features of the Port consists of construction of an offshore berth 700 m long and 65 m wide to receive vessels up to 4,500 TEU and the container stack yard (46 ha) to be developed by reclamation at Victoria Dock and Prince Dock. The container handling productivity will increase to 1.2 million TEU/year after completion of the project.

According to the information from Mumbai Port Trust, the trust has prepared the bidding of BOT basis for the Project and the bidding will be opened within several months.

2) Jawaharlal Nehru Port

JNPT has plans to develop a 4$^{th}$ container terminal at the west of GTI in two phases. In 1$^{st}$ Phase, 700 m container berth will be constructed at the reclaimed area and the existing BPCL Jetty will be integrated into the new berth structure. The container berth of 1$^{st}$ Phase will be connected to the reclaimed area by 5 approaches (Access Bridge) each 240 m long. In the 2$^{nd}$ Phase, the container berth will be connected to reclaimed area by 3 approaches each of 390 x 14 m, 685 x 14 m and 986 x 14 m. The container handling productivity will reach to about 2.0 million TEU each, after the completion of both phases. JNPT will decide whether implement or postpone the execution of 4$^{th}$ Container Terminal Project based on the progress of DFC (Dedicated Freight Corridor) project.

JNPT expects that a total container cargo handling productivity will be reached to about 8.0 million TEU when the 4$^{th}$ Container Terminal Project is completed. It is also possible to increase another 2.0 million TEU of container handling productivity if the gantry cranes are upgraded and berth depths are increased to -14 m at JNTC, NSICT and GTI. If all activities are completed in future, the container cargo handling productivity will be reached up to maximum 10 million TEU.

3) Kolkata Dock System

Kolkata Port Trust (KoPT) has improved the existing Berth No.4 and redeveloped it to the Container Terminal which covers an area of 30,000 $m^2$ at Kolkata Dock System (KDS). Kolkata Port Trust does not have further development plan of container terminal at KDS in the near future. The container cargo handling productivity at KDS will reach to 280,000 TEU in future.

The feasibility study of Diamond Harbor (DH) was carried out by Consulting Engineering Services PVT Ltd. in 2006. The project consists of construction of 3 multi-purpose berths with depth of -9.5 m. The container cargo handling productivity at DH will reach to 120,000 TEU in 2009 in accordance with the F/S report. According to the information from KoPT, DH will be operational by 2009 at least, but KoPT is expecting that DH can be operated within 2008, if it is implemented on BOT basis.

KoPT realizes that development of Diamond Harbor Development Project is categorized as the short term project and Sagar Port Development Project is categorized as the long term projects for KoPT in terms of improving the cargo distribution system in and around West Bengal. Although several studies for Sagar port has already completed, it has not taken shape to date.

4) Haldia Dock Complex

The construction of 2 multi purpose berths, Berth No.2 implemented by BOT scheme and another Berth No. 13 implemented by KoPT as port expansion plan, will be completed in April and September 2007 respectively. The construction of 2 oil jetties along Hoogli River, Riverine Jetty-1 in the north of Lock Gate and Riverine Jetty-2 in the north of 3rd Oil Jetty, will be completed in August, 2008 and March, 2009 respectively. The cargo handling productivity of those berths will be increased as shown follows.

- Multipurpose Berth (No.2) : 2.0 million ton
- Multipurpose Berth (No.13) : 1.0 million ton
- Riverine Barge Jetty-1 : 1.5 million ton
- Riverine Barge Jetty-2 : 2.5 million ton

The total cargo handling productivity will be reached to 49.22 million ton in March, 2009. It is expected that the container cargo handing productivity will reach about twice (300,000 TEU) as much as the present productivity in consideration of the above development plan.

5) Gujarat Pipavav Port

The features of port facilities for 1st Phase and 2nd Phase are shown in the following table. The construction of 1st Phase has already completed and 2nd Phase is being implemented currently.

**Table 5-4 The features of port facilities for 1st Phase and 2nd Phase**

| 1st Phase | 2nd Phase |
|---|---|
| Reinforcement of Berth : 394m | Construction of Berth : 350 m |
| Quayside Gantry Crane: 3 nos. (29 units/hr.) | Quayside Gantry Crane: 3 nos. (29 units/hr.) |
| Container Yard : 203,000 $m^2$ | Container Yard : 100,000$m^2$ |
| Reefer Plug : 250 | RTG Crane : 18 nos. |
| Depth : 12.5 m | Depth : 14.5 m |

Pipavav port has plan to develop the artificial excavated port having a total berth length of 2,200 m with berth depth of 15 m on the north of existing port facilities. It is expected that there will be 5 berths in the port. If 2 of 5 berths are allocated for container handling, the number of container berth will become 4 berths in addition to the existing berths. It is expected that the container handling productivity will be reached to about 2.5 million TEU in future if 3 gantry cranes are installed on each berth.

The cargo handling productivity estimated by Pipavav port for the period between 2005 and 2010 are shown as follows.

**Table 5-5 The cargo handling productivity estimated for the period between 2005 and 2010 of Pipavav port**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Container Yard Area (ha) | 11.8 | 11.8 | 11.8 | 16.3 | 24.3 | 32.3 |
| Port Productivity (TEU) | 180,000 | 210,000 | 430,000 | 640,000 | 1,000,000 | 1,350,000 |
| Maximum Productivity (TEU) | 404,308 | 419,014 | 670,923 | 1,024,054 | 1,646,784 | 2,064,703 |

6) Kandla Port

Kandla Port Trust has plans to develop port facilities such as wharfs, terminals, dredging etc. in future. The port is functional as an industrial port especially since there are some oil refinery facilities, chemical fertilizer plans, pipelines, etc. in and around the port. The port is planned to be developed as an industrial port on the west coast of India in the future and it will also handle container cargo as usual. Though the bulk cargoes such as dry bulk and liquid bulk are handled at Kandla port, Mundra port is specialized to handle container cargo in the western region.

Current development plans of the port include;

- Construction of 13th to 16th Cargo Berths
- Creation of Berthing and Allied Facilities off Tekkanea Tuna (Out side Kandla Creek)
- Setting up of Off-shore Liquid Terminal
- Improvement of Berth 1 to 6 (Dry Cargo)

It is expected that the container handling productivity will reach two or three times (about 500,000 TEU) of the present productivity (from the present as much as 170,000 TEU) in the future in consideration of a scaled port development plan.

7) Mundra Port

Mundra port is currently developing 2 container berths to be completed in December, 2006 and 4 bulk berths in July, 2007. With that development, the number of berth will become 12 berths in addition to existing 6 berths: 2 container berths and 4 bulk berths. The container handling productivity will reach twice as much as the present productivity (2.4 million TEU) after opening of new container berths.

The port has plans to develop the following berths in the future.

| | | |
|---|---|---|
| Coal Berth (1 berth) | : | To be completed within 2 to 3 years |
| LNG Jetty (2 berth) | : | To be completed within 3 years |
| Liquid Cargo Jetty (1 berth) | : | To be completed within 2 years |
| Container Berth (13 berth) | : | To be completed within 4 to 5 years |

As mentioned above, the port will have 29 berths: 17 container berths and 12 bulk berths. The port will become the largest container port in India after opening of all container berths. It is expected that the container cargo handling productivity will be reached to more than 10 million TEU, if all berths operate.

### 5.2.2 Future Container Cargo Handling Productivity

Table 5-6 shows the summary of potential container cargo handling productivity of target ports in the future. The productivity of target ports will be reached to about 24 million TEU: about 11.2 million TEU at Maharashtra, about 0.7 million at West Bengal and about 13.0 million TEU at Gujarat.

**Table 5-6 Summary of Potential Container Cargo Handling Productivity at Target Ports**

Unit: TEU

| | Maharashtra | | West Bengal | | Gujarat | | |
|---|---|---|---|---|---|---|---|
| | Mumbai | J.N. port | Kolkata | Haldia | Pipavav | Kandla | Mundra |
| Cargo Handling Productivity | 1,200,000 | 10,000,000 | 400,000 | 300,000 | 2,500,000 | 500,000 | 10,000,000 |
| Sub Total | 11,200,000 | | 700,000 | | 13,000,000 | | |
| Grand Total | 24,900,000 | | | | | | |

The detail study on "Container Traffic Demands and Shipping Routes for the Ports in western corridor" are presented in *Volume4 Technical Working Paper Task0&1, 5.*

## 5.3 FUTURE ROAD NETWORK DEVELOPMENT PLAN

### 5.3.1 National Highway Development Plan in India

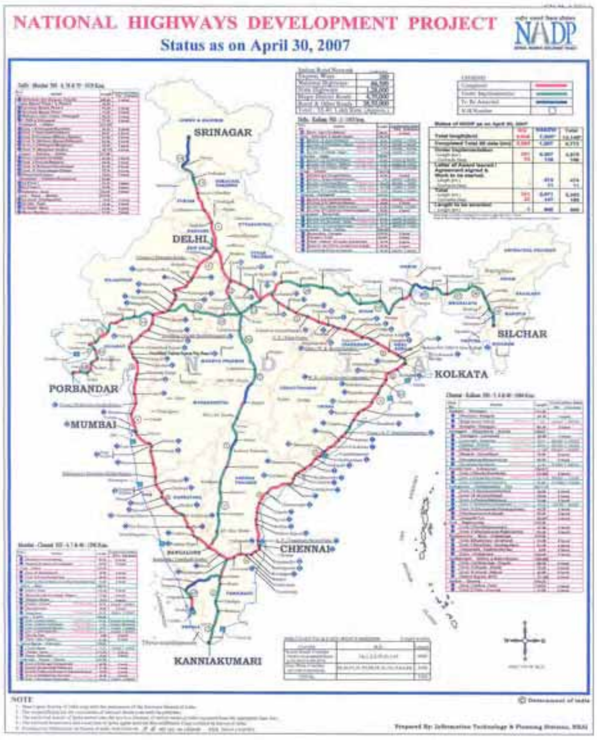
The management of the whole national highways in India is dealt with National Highways Authority of India (NHAI) under Department of Road Transport & Highways, Ministry of Shipping Road Transport & Highways (MOST). At present, considering the importance of the National Highways and the rapid increase in traffic, the Government has taken up the National Highways Development Project (NHDP), which consists of the following components.

**Table 5-7 The components of NHDP**

| NHDP Phase | Target | Length (km) | Completion Schedule |
|---|---|---|---|
| Phase I | The Golden Quadrilateral (GQ; 5,846 km) connecting the four major cities of Delhi, Mumbai, Chennai and Kolkata. | 5,846 | 2008.12 |
| Phase II | North-South and East-West corridors comprising national highways connecting four extreme points of the country. The North-South and East-West Corridor (NS-EW; 7,300 km) connecting Srinagar in the north to Kanyakumari in the south, including spur from Salem to Kochi, and Silchar in the east to Porbandar in the west. | 7,300 | 2008.12 |
| Phase III | The government approved NHDP-III to upgrade 10,000 km of national highways on a Build, Operate and Transfer (BOT) basis, which takes into account high-density traffic, connectivity of state capitals via NHDP Phase I and II, and connectivity to centers of economic importance. | 10,000 | 2012.12 |
| Phase IV | The government is considering widening 20,000 km of highway that were not part of Phase I, II, or III. Phase IV will convert existing single lane highways into 2-lane with paved shoulders. | 20,000 | 2015.12 |
| Phase V | As road traffic increases over time, a number of four lane highways will need to be upgraded/expanded to six lanes. The current plan calls for upgrade of about 5,000 km of four-lane roads. | 6,500 | 2012.12 |
| Phase VI | The government is working on constructing expressways that would connect major commercial and industrial townships. It has already identified 400 km of Baroda-Mumbai section that would connect to the existing Baroda-Ahmedabad section. The World Bank is studying this | 1,000 | 2015.12 |

| | | | |
|---|---|---|---|
| | project. The project will be funded on BOT basis. | | |
| Phase VII | This phase calls for improvements to city road networks by adding ring roads to enable easier connectivity with national highways to important cities. In addition, improvements will be made to stretches of national highways that require additional flyovers and bypasses given population and housing growth along the highways and increasing traffic. | N.A. | 2014.12 |
| Port Connectivity | This phase calls for improvements to port connectivity to access major ports facilities from national highways upgraded by Phase I and II. | 380 | |
| | Total Length (km) | 45,000 | |

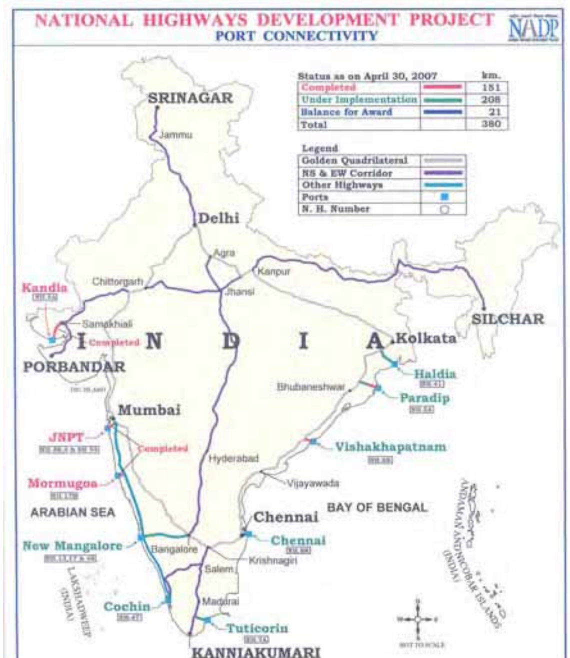
Source：National Highways Authority of India HP
http://www.nhai.org/roadnetwork.htm




The Golden Quadrilateral Corridor


NS & EW Corridor


Other National Highway




Port Conectivity

Source : National Highways Authority of India HP
http://www.nhai.org/roadnetwork.htm

**Figure 5-3 NHDP Maps**

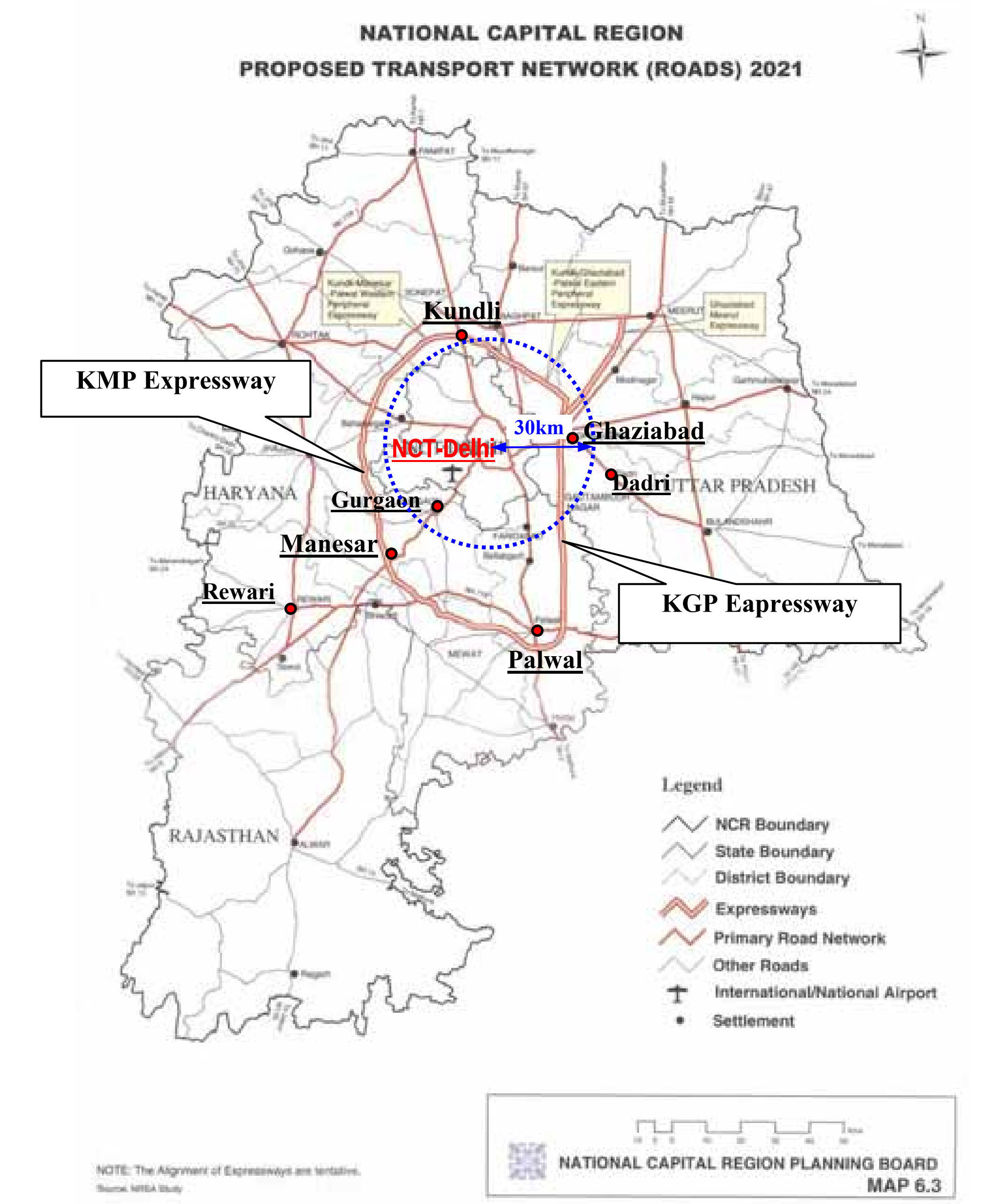
After this Project, whole national highways are improved to more than 2-lane widening including new installation of ring roads and bypass around major cities as well as upgrading to grade separation intersections in major cities and new development of expressway.

The other hand, other roads (state highways, major district roads, rural roads and minor roads) are improved by each state government and local government under international donors, WB and ADB.

### 5.3.2 Future road network development plan in National Capital Region (NCR)

The regional development master plan of target year 2021, “REGIONAL PLAN-2021 NATIONAL CAPITAL REGION”, was announced and published for the public by National Capital Region Planning Board in Ministry of Urban Development（MoUD）in September 2005. The concept and goal of this plan is mentioned in this report as follows; this regional plan seeks to achieve a balanced development of the NCR, by harnessing the spread of the developmental impulse and agglomeration economies generated by Delhi for harmonized, balanced and environmentally sustainable spatio-economic development of the NCR. The concept of NCR is inextricably linked with the goal of decongesting Delhi and at the same time bringing about harmonious and qualitative development in the NCR.

The installation of Ring Road in an approximate radius of 30 km is proposed in this report based on the exiting survey results as shown in the following figure. The 4 and 6-lane toll expressways, Kundli - Manesar - Palwal (KMP) Expressway and Kundli - Ghaziabad - Palwal (KGP) Expressway, will function as ring road in NCR and is under construction as BOT project by Haryana State Industrial and Infrastructure Development Corporation Ltd. (HSIIDC) of Haryana state. The function of circulation and accessibility to Delhi region will be considerably improved after these roads are constructed.




Source : REGIONAL PLAN-2021 NATIONAL CAPITAL REGION

**Figure 5-4 Proposed Transport Network (Road) 2021**

## 5.4 FUTURE DEVELOPMENT PLAN ON SOUTH AREA IN NCR

### 5.4.1 Gurgaon District

#### (1) Development plan of controlled area

The district development plan of controlled area up to 2021 is shown in the following figure. In this development plan, new industrial zone is designed in the western area beside the existing ones in east and central area. Regarding the ICD development, the 300 ha of railway siding area is planned in the western area of Garhi Harsaru Jn. At present, no trunk roads are connected to this area but some access roads to NH8 and industrial zone are planned in the future development plan.

## (2) ICD construction plan

A number of private ICD operators have plans to construct ICD complex in suburban area and one of them is due to open in April 2007. In addition to that, the cargo-cum-passenger terminal is planned at the south-west area of National Capital Territory of Delhi. The abstract of above plans is shown below.

1) Patli:

- ICD construction plan at about 8 km west from Garhi Harsaru Jn.
- Many private ICD operators will join the plan
- Adani is to open the new ICD in an area of 20 hectares on April 2007.

2) Bijwasan (National Capital Territory of Delhi):

- Cargo-cum-Passenger terminal construction plan at the adjoining area to the Delhi International Airport
- Land for ICD will be supplied to CONCOR
- Detailed description are mentioned in the Master Plan for Delhi 2021

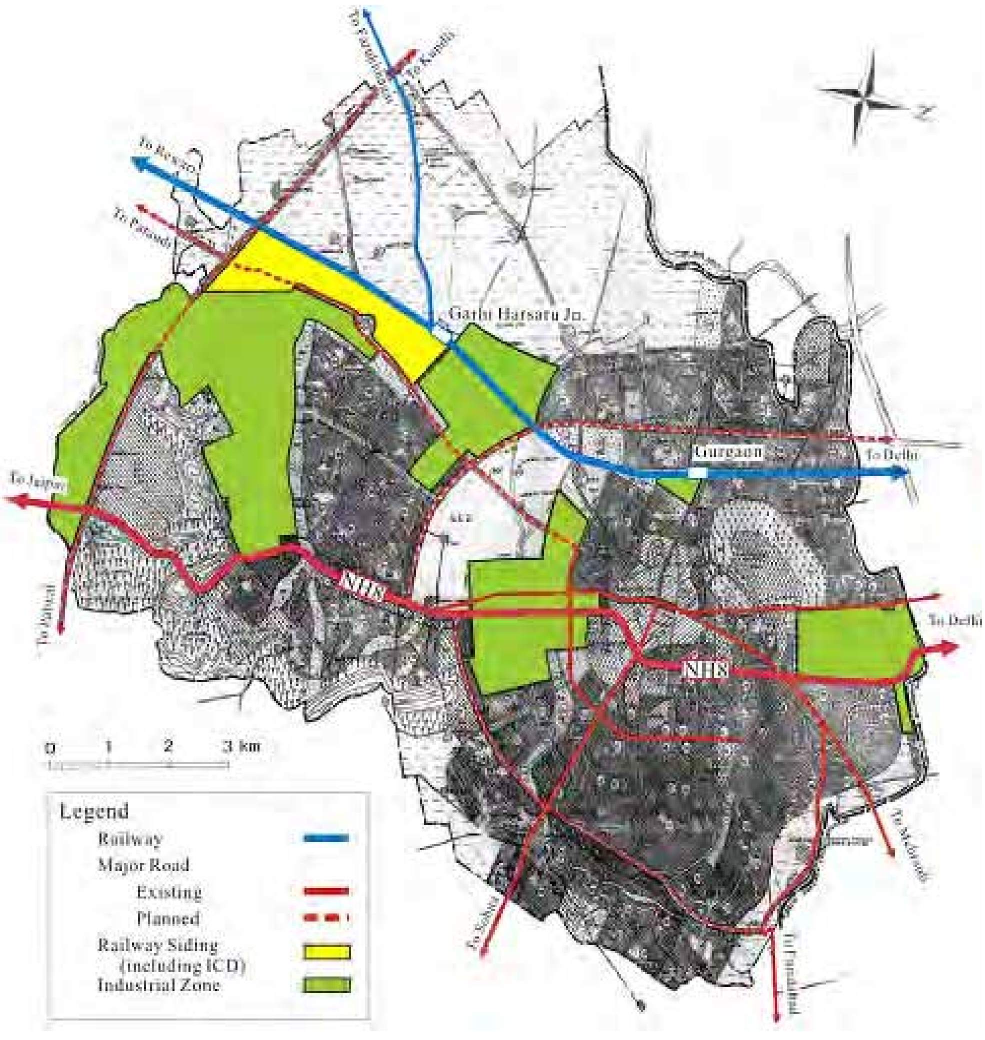



**Figure 5-5 Development Plan of Gurgaon District Controlled Area up to 2021**

### 5.4.2 Rewari District

#### (1) Development plan of controlled area

The district development plan of controlled area up to 2021 is shown in following figure. In this development plan, new industrial zone is proposed in the south east area, however, scale of it is smaller than Gurgaon. Regarding the ICD development, the 200 hectares of railway siding area is planned along the railway line towards Jaipur, at about 5km from Rewari Jn.

#### (2) ICD construction plan

CONCOR plans to construct new ICD in Rewari district. In addition, the new ICD is planned in the neighbouring area of Rajasthan state where the new industrial zone is planned mainly comprising of Japanese companies.

1) Rewari:
   - ICD construction plan at about 5 km south east from Rewari Jn.
   - Operation company: CONCOR
   - Detailed description are mentioned in the District Master Plan
2) Neemrana (Rajasthan State):
   - New ICD construction plan near the planned industrial zone mainly comprising of Japanese automobile related companies.
   - Future demand forecast: 600 thousand TEUs per annum

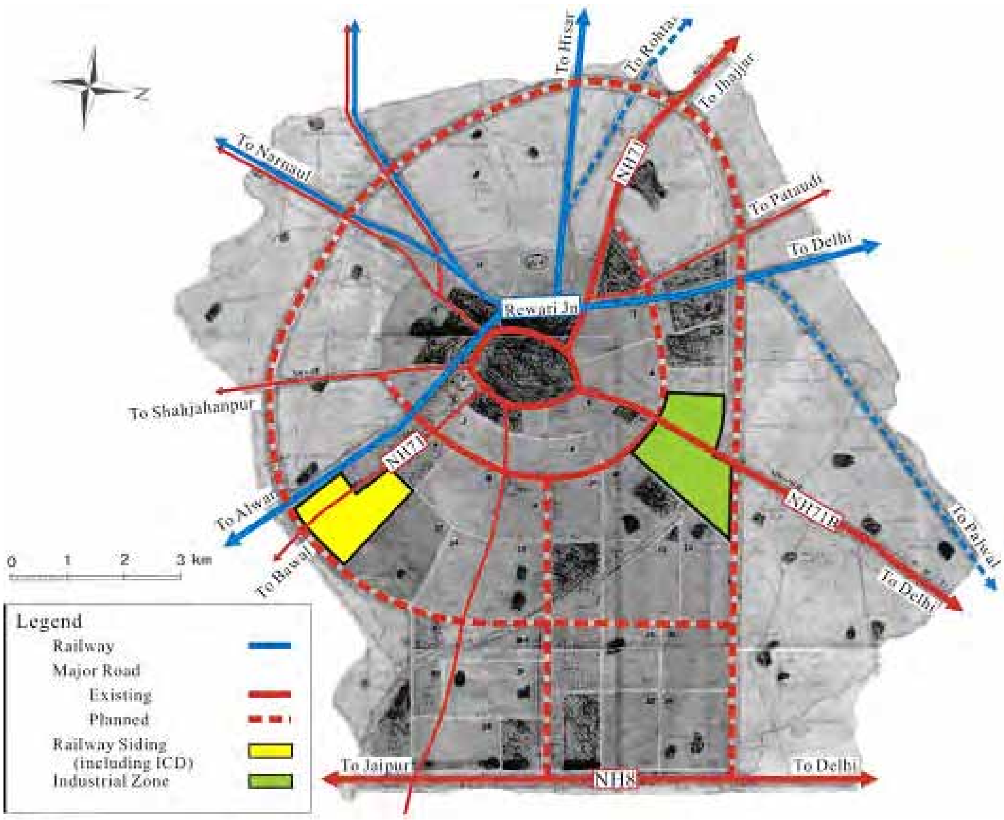
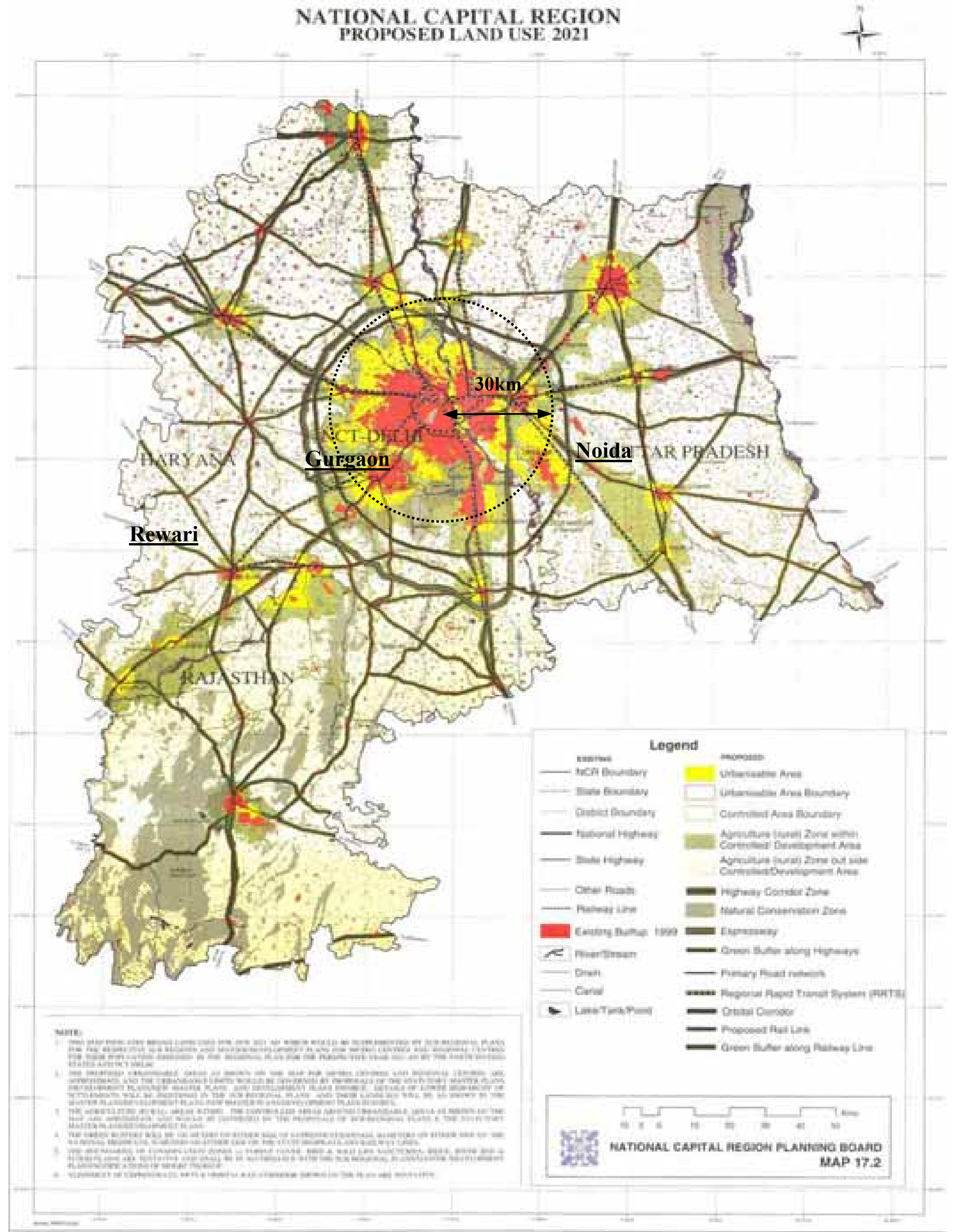



**Figure 5-6 Development Plan of Rewari District Controlled Area up to 2021**

### 5.4.3 National Capital Region

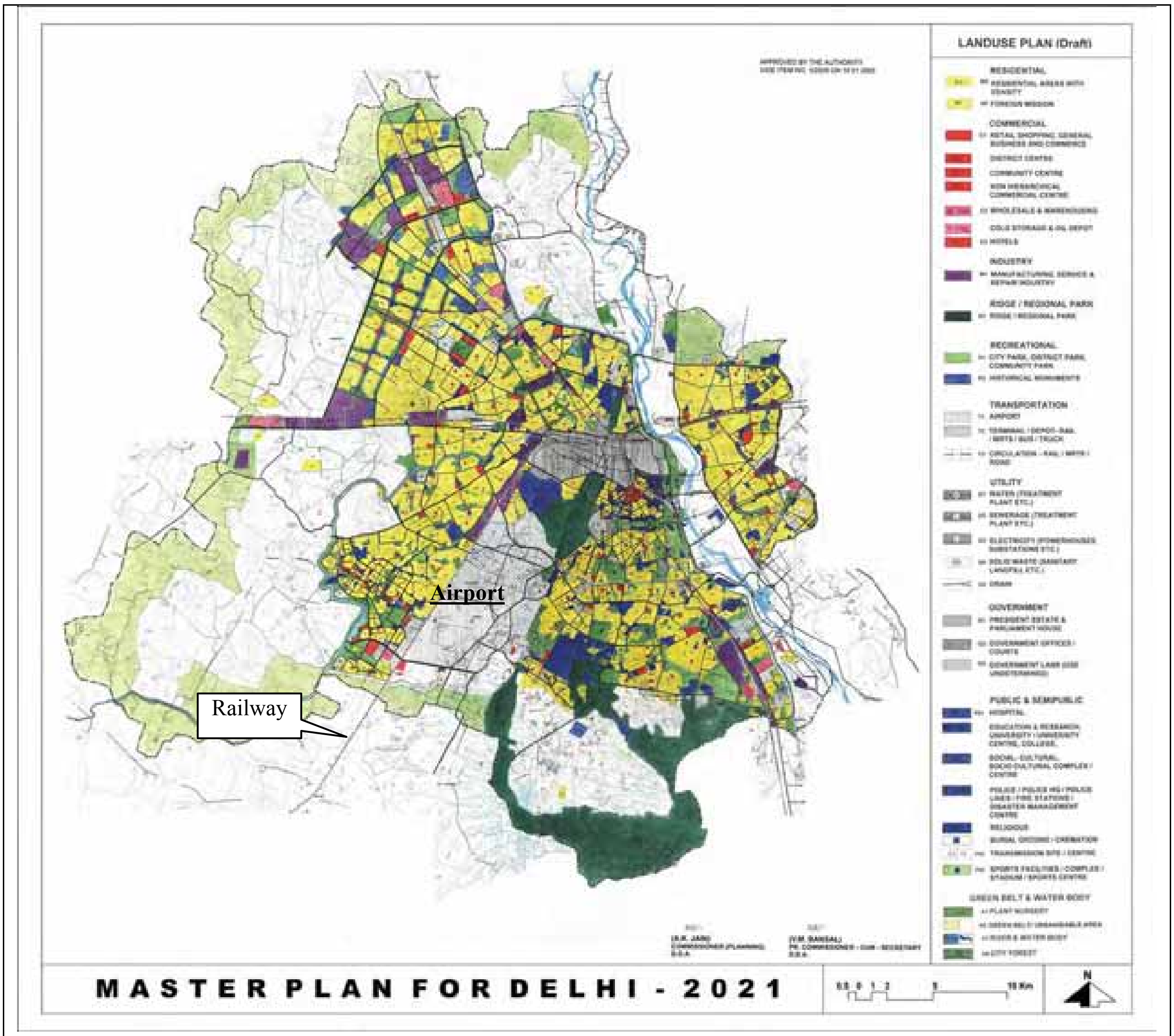
As mentioned previously, the regional development master plan of target year 2021, "REGIONAL PLAN-2021 NATIONAL CAPITAL REGION", was announced and published for the public by National Capital Region Planning Board in Ministry of Urban Development (MoUD) in September 2005. The concept of NCR is inextricably linked with the goal of decongesting Delhi and at the same time bringing about harmonious and qualitative development in the NCR. The proposed future land use plan Year 2021 for NCR in this report is shown in the following figure;




Source : REGIONAL PLAN-2021 NATIONAL CAPITAL REGION

**Figure 5-7 Proposed Land use 2021 in NCR**

The map of proposed land use plan 2021 in Delhi is declared on the Internet as shown in the following figure. In this map, yellow and red colored markings are residential and commercial zone, purple colored markings are industrial estate, green and blue colored markings are parks and historical places. The other hatched marking zone is shown as public opening space for railway and airport. There is a plan of new ICD to be constructed on south side of International airport.

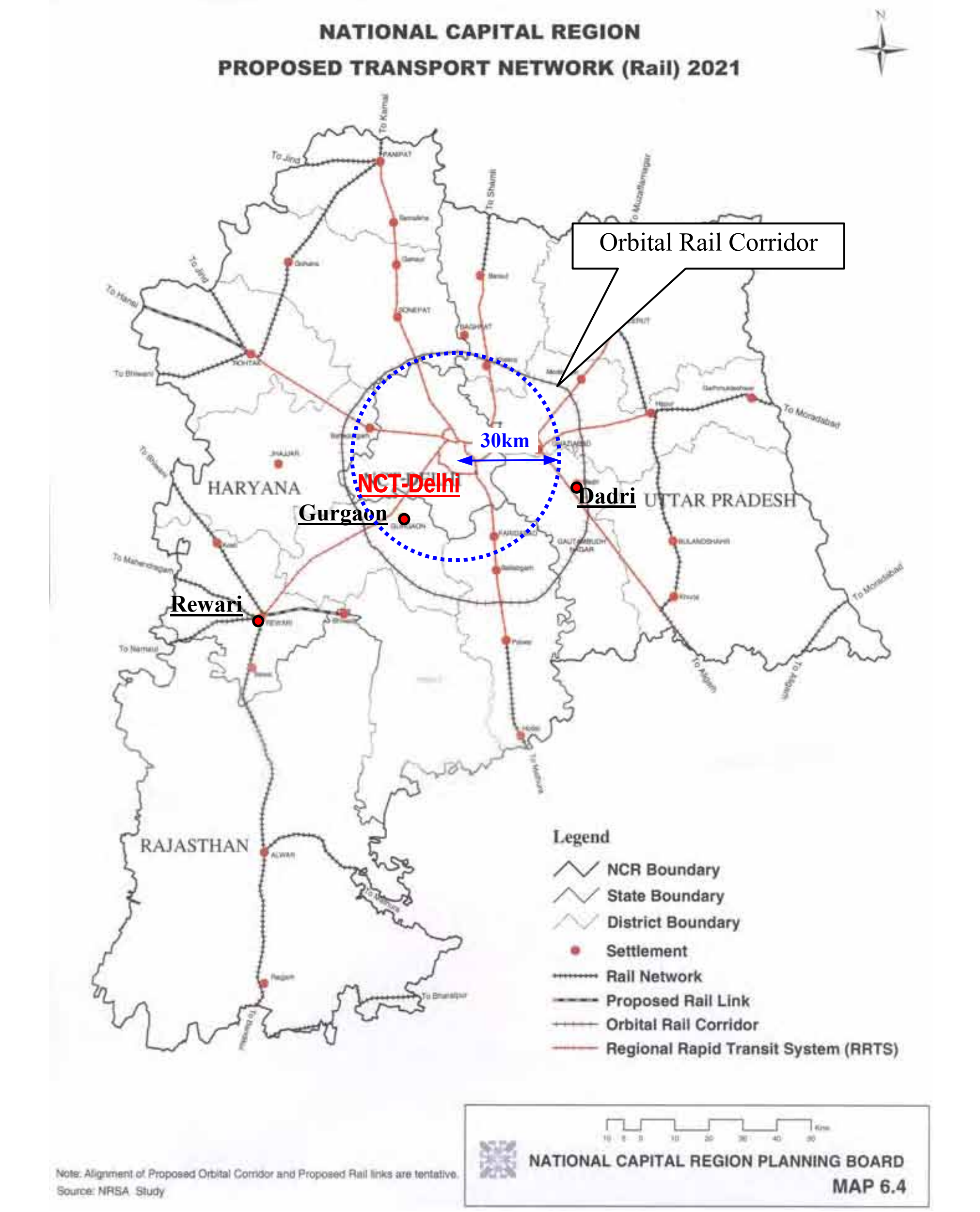



Source : REGIONAL PLAN-2021 NATIONAL CAPITAL REGION

**Figure 5-8 Proposed Land Plan 2021 (Draft) in Delhi**

The installation of Orbital Rail Corridor in an approximate radius of 30 km are proposed in this report based on the exiting survey results as shown in the following figure.

The function of circulation and accessibility to Delhi region will be considerably improved after this orbital rail corridor is complete.




Source : REGIONAL PLAN-2021 NATIONAL CAPITAL REGION

**Figure 5-9 Proposed Transport Network (Rail) 2021**