Research and Development

RDSO is the sole R&D organisation of Indian Railways and functions as the technical advisor to Railway Board, Zonal Railways and Production Units. One of the major roles that RDSO has played is that of developing and maintaining standards and specifications which ensure that all different technologies are able to work together as a system, which permits Indian Railways to operate seamlessly without any technology limitations.

RDSO also offers international consultancy services in matters pertaining to design, testing and inspection of railway equipments as well as survey for construction of new lines. The significant accomplishments of RDSO in the sphere of research & development have always attracted worldwide attention.

Some of the important activities & projects undertaken/completed during the year are given below:

Safety

- **Development of Electronic LC Gate Communication System with Voice Logging Facility**: In order to provide a simple solution having provision of voice logging and recording for communication between Station Master and Gateman, existing Specification for LC Gate System has been upgraded. This equipment also has provision of playback facility in Station Master unit under lock and key arrangement. Field trials were conducted on KRCL.

- **Development of Train Collision Avoidance System (TCAS)**: TCAS is meant to provide protection by preventing trains to pass signal at Danger (Red), excessive speed over turnouts/speed restrictions and to avoid the situation in which more than one train are on the same track. It also provides assistance to Loco Pilots by means of real-time display of signal aspects in Loco Pilot’s cab. This includes key features of ACD & ETCS TPWS at much lower cost. It is based on the determination of location of trains through distance traversed from RFID tags installed on track and transmission of signaling related information from stationary unit such as Station Interlocking. The specification for the first phase i.e. Absolute Block System has been finalized. In October, 2012, the Concept Field Trial has been conducted in Secunderabad Division of SC Railway.
• **Development of Train Protection and Warning System (TPWS):** TPWS is a continuous supervision system that provides safety in train operations by dynamically monitoring the speed of the train against specified limits and eliminates risks arising due to cases of Signal Passing at Danger (SPAD). The system has been commissioned on 51.75 route kilometers of Chennai-Gummidipundi section of Southern Railway till 2011-12 and was under commercial trial in Hazrat Nizammuddin -Agra section of NC Railway. TPWS is also being implemented in Kolkata Metro, in the year 2012-13.

• **On-Board Display of Signal Aspect (OBDSA):** OBDSA is intended to provide display of line side signal aspects inside Loco Pilot’s Cab. It would be a portable device to be carried by crew on duty. It shall be deployed in Absolute Block Section Territory and OBDSA equipped Locomotive shall be interoperable in TCAS (Train Collision Avoidance System) equipped section. Function-wise, OBDSA has been envisaged as subset of TCAS but unlike TCAS, it does not have braking interface to Locomotive and would be easier to install.

• **Development of Fuse Auto Changeover System (FACS):** With the intention of reducing down time and to monitor the status of various fuses, a new specification for Fuse Auto changeover system has been developed. The system has one standby fuse for every signaling fuse. The standby fuse automatically comes in signaling circuit in case the main fuse is blown. Remote audio visual extension of alarm is also extended for immediate attention of the maintenance personnel. Provision for sending SMS separately for main and standby fuse blown events to designated GSM numbers is also made.

• **Development of EP Assist Brake System:** To overcome the problem of delayed propagation of brake wave to last vehicle particularly in longer train resulting in increased braking distance and uneven coupler forces, RDSO has developed EP Assist Brake System in which brake pipe pressure is controlled by an electrical signal generated from driver’s brake handle resulting in simultaneous brake application on all vehicles irrespective of train length. Application of this system has also been started on a WDP4D loco at DLW.
• **Safety Device for Aluminum Gear cases used in WAP5 Locomotives:** To avoid the risk of falling of bottom half of aluminum gear case online in the event of breakage of mounting lug in WAP5 class of locomotives due to sudden impulse loading, a safety device has been developed and a modification sheet has been issued for use of the safety device as an emergency support.

• **Development of LED Based Light Unit for SLR Coaches:** Conventional luminaries provided in SLR coaches get broken due to over loading of luggage up to the roof which is a fire hazard. Therefore, development of LED based light unit for SLR coaches has been undertaken and successfully completed by RDSO. These LED based light units are under field trials on Northern Railway.

• **Automatic Smoke/Fire Detection with Alarm System to be Fitted in AC LHB Coaches Over Indian Railways:** Consequent upon Railway Convention Committee’s suggestion that a reliable and efficient fire detection system to avoid fire hazards be developed, a field trial with Aspiration type Automatic Smoke/Fire Detection with Alarm System on one Rajdhani rake has been conducted to access early warning for potential fire hazard. During the year 2013-14, additional 20 rakes of Rajdhani/Shatabdi Express coaches shall be provided with automatic Smoke/Fire Detection with Alarm System.

• **Development of New Tests of Memory (re-construction):** New tests of Memory (reconstruction), Selective Attention and Perceptual Speed for measuring critical cognitive attributes of drivers and ASMs having bearing on their safety performance have been developed for enriching test batteries.

### Passenger Amenities

• **Development of Induction Heating Based Pantry Equipments:** RDSO has developed the scheme for provision of induction heating based cook tops in non AC coaches, Air-conditioned self-generating coaches and LHB EOG type Rajdhani Express pantry cars. Induction heating based cooking technology, which is cheaper than LPG or resistive heating element based cooking, is absolutely safe from fire on spillage of cooking oil and also the direct heating of container enhances overall efficiency.
Further, this system is odourless, time saving, having precise heating control and easy to operate by cooking staff.

- **Development of LED Based Head Code & GPS Based Public Information System for EMUS & MEMUS:** RDSO has developed the programmed LED based head code to replace the existing tin plate/scroll cloth type head code, and provide GPS based passenger information system.

- **Provision of Mobile/Laptop Charging Point in MEMUs:** RDSO has designed and included the provision of 04 Mobile/laptop charging points in motor coaches and 06 charging points in trailer coaches in the specification of MEMU coaches.

**Infrastructure**

- **Issue of Guidelines to Zonal Railways for Developing Infrastructure to Home 200 Electric Locomotives in Shed:** RDSO has prepared and issued a Technical Circular for developing infrastructural requirement for homing 200 electric locos in shed in order to facilitate Zonal Railways in planning for creation of new sheds and expansion of existing ones.

- **Development of Capacity Optimization & Simulation Tool (COST):** This development, being jointly done by the RDSO and IIT/Mumbai, comprises of design of basic software tool for computation of line capacity of any Indian Railway section taking into consideration various parameters like type of block working, block length, signal spacing, speed restrictions, and other parameters that would have an effect on line capacity. The tool would be used for examining the effect on line capacity of the technological improvements like Intermediate Block Signaling, introduction of new stations, doubling/tripling/quadrupling, etc. and would assess the extent to which section line capacity could be increased.

- **Development of LED Signals for Specific Requirement in Tunnels for Metro Railway, Kolkata:** Signals installed inside tunnels over Metro Railway, Kolkata are having different dimensions than signals used over Indian Railways. Prototypes were developed and evaluated at RDSO and so far 50 of these signals are working satisfactorily in Kolkata Metro.
• **Screening of High Speed Train Drivers for Rajdhani/Shatabdi Express Trains:** The screening of Loco Pilots for their deployment on High Speed Trains having speed more than 110 kmph, is done on indigenously developed Computer Aided Drivers Aptitude Test equipment comprising of 17 tests for assessment of various required attributes. So far, more than 1,350 Loco Pilots have been screened on this system on Indian Railways.

**Operational Efficiency**

• **Development of BG High Speed Self-Propelled ART (SPART):** RDSO has developed BG, high speed (120 kmph), 3-coach SPART to accommodate all re-railing equipment, cold cutting equipment, medical facilities and upgraded kitchen.

• **Design and Development of 2400 BHP Multi Genset WDM2G Locomotive:** RDSO has designed and developed energy efficient, low emission, 2400 BHP broad gauge Multi-Genset locomotive fitted with Gensets and Microprocessor based control system.

• **Development of 4500 HP Diesel Loco with Hotel Load Feature:** 4500 HP diesel loco with Hotel Load feature has been developed to cater to the electrical load of all lights, fans, air conditioning of coaches and pantry cars. This shall enable attachment of an additional coach in lieu of one power car and thus increase throughput.

• **Development of 4500 HP Dual Cab WDG4D Freight Locomotive:** RDSO has designed a dual cab WDG4D locomotive for IR. Because of increased axle load and length, the existing spring of WDG4 is also required to be modified. A new spring has been designed which has better lateral and vertical stiffness, besides meeting the different safety requirements for dynamic performance. This new spring will provide better riding characteristics. Prototype locomotive has been manufactured and turned out by DLW and has cleared oscillation trials.

• **Development of 1600HP AC-AC Diesel Electric Multiple Unit (DEMU):** RDSO has developed 1600 HP DEMU consisting of 10 cars viz. 1DPC + 8TC+1DPC with 105 kmph maximum operational speed. It is equipped with AC-AC transmission, Fault logging and Diagnostic system and Microprocessor based control system.
The prototype DEMU has been manufactured and turned out by ICF. This will reduce maintenance and downtime, saving in man hour due to more optimized and reliable traction control system.

- **Development of Modified Bogie for WDP1 Locomotives:** As Diesel Loco Sheds had been reporting problems associated with bogies of WDP1 locomotive, modifications were devised by RDSO and one WDP1 locomotive was modified in TKD shed. To judge the performance, oscillation trial has been done successfully upto a speed of 135 kmph. This new design will improve the reliability of WDP1 locomotive and reduction in down time.

- **Development of High Capacity Compressors for WAP-4 to Address the Problem of Low MR Air Pressure While Hauling Duranto Trains:** Railways have been reporting problem of MR pressure drop on line ever since ‘Duranto’ train was introduced on Indian Railways while working with WAP-1/WAP-4 locomotives due to use of air springs and control toilet discharge system in these trains. In view of enhanced air requirement of Duranto trains, proposal for provision of high capacity oil free compressor (2x1750 LPM) as under-slung for all future manufacture of WAP-4 locos by CLW and on-board fitment of high capacity oil free compressor (2x1750 LPM) by Zonal Railways has been approved.

- **Development of Distributed Power Wireless Control System (DPWCS) for Convention Electric Locomotives:** Specification of DPWCS with braking features from remote loco for Electric locomotives has been finalized. Type tests have been carried out at firm’s premises and the material is under extended field trials at Electric Loco Sheds at NGP, TATA, BIA, Kazipet.

- **Instructions for Loco Pilots in Locomotives Fitted with 180 KVA SIV:** To tackle cases of punctuality loss on account of intermittent tripping of 180 KVA SIV, a separate SIV reset switch has been provided on the SIV panel, which can be used by Loco Pilot instead of putting HBA in ‘OFF’ position and then in ‘ON’ position for resetting of SIV.
• **Reverse Cycle Air Conditioning System**: Presently, the air conditioning system is having heater coils which provide warm air inside the coach during winter. Every year, there are few cases of smoke emission from these heating coils. RDSO has designed and developed an air conditioning system without heating coils which will provide warm air to the passengers in winter. Coaches with reverse cycle operation, which works on the concept of reverse cycle operation of refrigeration system, are more energy efficient and the possibility of fire is also eliminated.

• **Provision of Capacitor Bank in LHB EOG AC Coaches of Rajdhani/Shatabdi Express Trains for Augmentation of coaches**: The scheme for providing capacitor bank in LHB EOG AC coaches of Rajdhani/Shatabdi Express trains for improving power factor has been designed and developed. With the introduction of the power factor correction scheme, electrical load capacity of the Rajdhani/Shatabdi trains has been increased. The cost of this modification is very low but the return in the form of extra revenue is very high as now two additional coaches can be attached with the existing Rajdhani/Shatabdi trains.

• **Development of V-belt Driven Permanent Magnet (PM) Alternator**: Presently, LHB coaches in spite of higher speed potential and safety, are limited to EOG/HOG version of train services due to space constraints for fitment of self-generating alternator on the bogie fitted with disc brakes. Permanent Magnet alternator has inherent advantages of smaller size and lower weight over conventional alternators. RDSO has developed 25/30kw Permanent Magnet (PM) alternator which can be fitted in LHB bogie. Two PM alternators along with their controllers fitted on a coach are successfully running in field for the last one year. This development enables IR to develop self-generating LHB coaches in future.

• **Development of Standby Unit to Improve the Reliability of ERRUs**: Standby circuit has been developed to make available 75% electrical power to the coach in case the main ERRU becomes faulty. There is a provision in CIP/terminal box to switch over to the standby circuit in case main ERRU goes defective. The standby circuit has been successfully tried in the field.
• **Design & Development, Fabrication, Supply, Testing and Commissioning of Stainless Steel AC EMU Coaches:** RDSO has developed stainless steel AC EMU coaches indigenously with BEML for the first time in the country. The complete car body is made out of austenitic stainless steel with high corrosion resistance property (except bolster region). Use of stainless steel enhances the aesthetics of car body and greatly reduces the maintenance. One rake has been successfully running in Eastern Railway since 10.09.2012. Manufacturing of second rake is in progress at BEML, Bengaluru.

• **Introduction of Three Phase Propulsion System on EMUs/MEMUs:** Energy efficient state-of-the-art 3-phase IGBT based technology with maximum permissible speed of 100 kmph and the improved passenger amenities on AC-DC EMUs has been introduced in Mumbai Suburban sections. Under the GP-194 and MRVC Phase-I, World Bank funded project, 115 rakes of 12 cars have already been introduced on Central and Western Railways. Further, seventy two new AC EMU rakes will be introduced under MRVC Phase-II project during the year 2013-14 & 2014-15. Introduction of three phase propulsion system on Indian Railways has resulted in regeneration of energy of more than 35%. With additional power availability, features like improved ventilation, better illumination have been added for passenger comfort. Stainless steel grab handles, partitions, ergonomic design of driving cab, GPS based public address system are the other salient features of new EMU stock for Mumbai area. To enhance the passenger carrying capacity, first 15 car 3 phase AC/DC EMU has also been introduced on both Central & Western Railways. Based on the performance and energy saving achieved through three phase propulsion system in Mumbai area, new specification has been framed to introduce the three phase electrics on EMUs/MEMUs for other Zonal Railways also.

• **Modeling and Validation of Interlocking for Railway Signaling Systems:** Object is to develop tools to improve the reliability & safety aspect of present EI systems. With this model, conversion and verification of safety rules for signaling system based on yard plan, control table and generic signaling circuits shall be possible.
• **Development of Online Insulation Monitoring (OLIM) System**: Object is to develop alternative of Earth Leakage Detector with more reliable and efficient online insulation monitoring system for signaling cable.

• **Stress Management**: For controlling adverse effect of stress by making people aware of various stressors and remedial measures to combat stress, RDSO has taken initiative for stress management for the benefit of staff.

• **Exclusive Website for Selection of Safety Category Staff of Indian Railways**: Exclusive website ’irptd.org.in’ has been developed and launched which depicts the details pertaining to patterns of Aptitude Tests for selection of safety category staff on Indian Railways and practice tests for the candidates besides highlighting the activities of the Psycho-tech Directorate of RDSO. This will help the prospective candidates to get acquainted with the types of test items asked in the Aptitude testing.

• **Crew Management System**: A study has been taken up for assessing the additional functionalities which can be incorporated in the existing crew management system. This would facilitate proper information, advance planning and monitoring.

• **Increasing Speed Potential of BOXN Wagon**: In order to increase the speed potential of BOXN wagon in CC+6T+2T/CC+8T+2T configurations, design of BOXNHAM wagons has been issued. Conversions of existing wagons to these wagons are progressively planned in a phased manner through Railway Board’s Rolling Stock Programmes. Following this conversion, the wagon shall be fit to run at 100 kmph (in empty) and 75 kmph (in loaded) in above mentioned configuration. Six rakes of BOXNHAM wagons have already been put into service.

• **Conversion of Existing Un-regulated OHE to Regulated OHE**: The existing OHE of Central & Western Railways is un-regulated and is about 88 years old. As per direction of Railway Board, RDSO has prepared design document for conversion of existing un-regulated OHE to regulated OHE and advised them in Feb., 2013. After conversion, the regulated OHE will give higher speed potential and less maintenance.
Indigenous Development

- **Development of Indigenous Crankshaft for 16 Cyl. HHP Loco**: RDSO is providing technical guidance and carrying out inspection of 5 number of prototype crankshaft. First prototype Crankshaft has been cleared by RDSO, which was successfully fitted on loco by DLW. IR shall save foreign exchange with this indigenization.

- **Development of Indigenous Computerised LCC (CLCC) for DEMUs**: RDSO has developed computerized LCC (CLCC) for AC/DC Diesel Electrical Multiple Units (DEMUs) with the help of an indigenous source. This is an important import substitute for which there was only one source, M/s GAC / USA. This cost effective development will reduce maintenance, loco downtime and save the foreign exchange.

- **Loco Performance Simulation Software**: RDSO is developing Loco Performance Simulation software in association with IIT Kanpur. This software will help Railways in simulating the various conditions available in Railways and assessing train performance.

- **Insulation Scheme for Rewinding of 3 Phase Traction Motor Used in AC/DC EMUs in Mumbai**: Traction motors type ITB 2022-0T A03 have been working on AC/DC EMUs with SIEMENS electrics supplied to CR and WR against GP-194 and MRVC projects since 2007 onwards. Similarly, TM types DMKT 53/42 have been working on AC/DC EMU rakes with BHEL electrics on CR for more than one decade.

- **Indigenous Development of Multi Section Digital Axle Counter**: Project for development of DAC (SSDAC & MSDAC) is in progress in collaboration with CSIR and CEL. SSDAC has been developed and being supplied to Zonal Railways on regular basis. Field trial of indigenous Multiple Section Digital Axle Counter (MSDAC) is completed at Faridabad (Northern Railway). Based on satisfactory trial at Jaitipur, extended field trial for 10 systems has been taken in 2012-13.

- **Development of Block Proving by Axle Counter (BPAC)**: Provision of BPAC will reduce dependence on human element in train operation and thus will improve safety. BPAC using UFSBI & SSDAC for single line &
double line has been developed with two sources till 2011-12.

- **Design & Development of Electronic Interlocking (EI) System:** With development of modern fault tolerant and fail-safety techniques, electronics and particularly microprocessors have found acceptance in the area of Railway Signaling world over including Electronic Interlocking. The features like software based interlocking logic, less wiring, easy alterations, self diagnostic, in-built data logger etc. make it maintainer-friendly. Two types of indigenous EIs are being developed. Now, new specification of EI for big yards (more than 200 routes) has been finalized.

- **Development of Conduit System for Cable Management in Passenger Coaches:** Flexible polyamide based conduit for passenger coaches has been indigenously developed to prevent progression of fire in case of short circuit. Earlier this item was being imported at higher cost, polyamide conduits are non-inflammable as this material does not contain halogens and is also non-toxic.

- **Metro Railway, Kolkata:** State-of-the-art air conditioned rakes for Kolkata Metro have been developed, which commenced commercial services between Dum Dum and Kavi Subhash. Design clearance for these rakes has been accorded by RDSO. RDSO was also involved extensively in commissioning of these rakes and was instrumental in identification & setting right the integration issues of various components.

**Inspection and Quality Audit**

- **Cross-wind Stability of Pantographs:** RDSO has carried out wind tunnel test of pantograph for two additional cross wind configurations, namely wind incidence angle of 45° and 90°, in addition to normal configuration as specified in IEC. The wind tunnel tests have been performed at IIT/Kanpur to evaluate cross wind effect on pantograph, which was found stable at speed up to 200 kmph for entire configuration of wind incidence angles, i.e. longitudinal and lateral direction of wind.

- **Quality Audit of Fitment and Maintenance of CTRB:** Detailed Quality audit of fitment and maintenance
of CTRB has been carried out at a number of railway workshops and wagon builders. Following the audit, recommended practices for POH workshops, ROH depots & Yard Examination as regards inspection, testing and maintenance of CTRBs of Freight Stock have been issued for the benefit of all concerned.

Consultancy

- **Design & Development of New Type of Bi-modal Wagon ‘Road Railer’**: A new type of bi-modal wagon ‘Road Railer’ is going to be introduced soon on Indian Railways. Detailed design of the same has been approved by RDSO and the wagons have been manufactured. Introduction of such services will help in attracting new traffic which requires door to door collection.

- **Consultancy to Metro Railways**: Consultancy to various Metro Railways is provided on a regular basis depending on the requests from different Metro Railways all over the country including DMRC (Delhi Metro Rail Corporation), DAME(Delhi Airport Metro Expressway), MOOPL(Mumbai One Operation Private Limited), CMRL (Chennai Metro Rail Corporation limited) etc. In the current year, a total of 2,726 Station controllers and Train operators were tested for different Metro Railways.

Tests and Trials

- **VSAT Based Train Control Communication System**: RDSO along with IIT/Kanpur has undertaken a UIC funded project for proof of concept trial of “VSAT based Train Control Communication System” for control circuit working in remote & isolated locations in difficult terrains where maintenance and restoration of control communication is very difficult due to frequent cable cuts/outside interference/other natural disasters etc. The omnibus features (i.e. all the users or subscribers connected to a single speech channel and ringing to be effective even when way-station telephone is off-hook and way-station, once lifts the handset, becomes part of ongoing conversation on control circuit) of Train Control Communication with VSAT Communication, (which is TCP/IP protocol based data communication) was demonstrated.
Trials were conducted at four way-stations of NF Railway, which were provided with VSAT Communication System with IP Telephone and controller telephone at Lumding Division and it was found that time delay is involved in communication and that such arrangement may be used only at locations where other established communication arrangement for train control communication (with almost no time delay) cannot be provided.

- **Trial of 2G/3G Bandwidth Aggregations Based Internet Access in Running Trains:** Testing and performance evaluation of Wi-Fi Internet Access on 9 coaches of one rake of New Delhi-Sealdah Rajdhani Express was carried out during the free of cost trial. In this trial, eight 2G/3G GSM/CDMA SIM were used to provide Internet facility on running trains with the help of Communication Control Unit (CCU), which aggregates available Bandwidth by GSM/CDMA service providers. Salient features of the system are :-
  - Antenna which are installed on the roof of Train interact/communicate with Basic Transceiver Station (BTS) during moving of train & take signal from BTS.
  - Communication Control Unit (CCU) has four combiners and it aggregates the available bandwidth from all the service providers.
  - Two Access Points (AP) were used in one carriage for providing internet to the user inside the carriage and provide the Inter Carriage Link without wire.
  - Power Supply was taken from carriage for Communication Control Unit (CCU) and Access Point (AP).
  - Each Access Point has two Antenna one (2.4GHz) for user link and other (5GHz) for Inter Carriage Link.
  - One carriage provides Internet facility with wire between two carriages for trial and demonstration purpose.

- **Design & Development of Higher Axle Load Wagons for Dedicated Freight Corridor:** Indian Railway is going to construct Dedicated Freight Corridor in the near future. Higher axle load wagons with pay to
tare comparable to international standards and designed and constructed with latest techniques will be required for operating on DFC. For the same, a contract through a global tender for design and development of 25 T and 32.5 T wagons has been signed and work has begun on the contract. Up-gradation of design capability of RDSO is also covered in the scope of work of this tender. For the first time on Indian Railways, a real time assessment of Load Environment of freight stock has been carried out through instrumentation of an actual wagon and its operation (including tippling) on IR for 16000 km. Assessment of dynamic augment, buff and draft forces using instrumented couplers and assessment of lateral/vertical/long wheel/rail forces were also done. The final report on the Load Environment Spectra of existing IR wagons along with comparison with North American (AAR) load spectra has been submitted. This has made available the first-ever load spectra for freight operations in IR. The report includes extrapolation of this load spectra to deduce forces expected to be encountered during operations of 25 T axle load wagons on IR.

- **Development of Mechanized Vehicles for Railway Electrification:**
  - Contract has been awarded for manufacture and supply of 4-Wheeler Mast Erection Machine Vehicle (MEMV), after prototype inspection and clearance for oscillation trial. This will help in mechanization of OHE works.
  - After successful oscillation trial on the 4-Wheeler Diesel Hydraulic (underslung) Tower Wagon at Secunderabad–Wadi Section of SCR, prototype clearance has been granted and bulk manufacturing of 4-Wheeler Tower Cars has been advised. This will help in easy and fast maintenance of OHE of Indian Railways.

- **Reliability Improvement of IPS** To improve the overall reliability of IPS, a modification plan was undertaken to achieve major modifications and reliability improvement measures in all the IPS systems working in the field, which has almost been completed by all the OEMs. In order to have further reduction in failure rate due to frequent supply
fluctuation/high voltage surges, an isolation transformer was provided at the input of IPS in various railways for the field trial. To reduce the failures related to LVDS, field trial of manual bypass of LVDS are being conducted where IPS are installed with LMLA batteries only.

- **Trial of Biaxial Geogrid on SC Railway and W. Railway:** Railway Board has ordered extended field trials of Biaxial Geogrid in SC Railway and W. Railway. RDSO has sent trial specification of Biaxial Geogrid to both the Zonal Railways. On W. Railway, laying of Geogrid was carried out between station Khachrod (KUH) and Runkhera (RNH) of Godhra–Nagda Section, Ratlam Division, in March-2013. Trial is under process on SC Railway.

- **Non-destructive Testing of Bridges:** RDSO has conducted non-destructive tests on 5 bridges (1 in NR, 1 in NCR and 3 in NWR) during the year to assist railways in finding solutions to problems in bridges. RDSO has also issued detailed guidelines for use of High Strength Friction Grip (HSFG) bolts as a substitute for rivets on bridges. This will help upgrade the technology and reduce the erection time for the bridges besides improving the quality of work. RDSO conducted two trainings on fabrication erection of steel girders at Mughalsarai/Manmad and one training on NDT at Lucknow for disseminating information on safety related issues.