Tubular Modular Track
Maintenance Manual

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Authorization of Maintenance Manual – Tubular Modular Track

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TT/QMS/103/ISO Rev 1	November 2015	
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Reference Documentation

Number	Document Name
BBB0481 VER 2	MANUAL FOR TRACK MAINTENANCE (Latest edition)
TT/QMS/104/ISO	Aluminothermic welding specification and Procedure

Disclaimer

Content

1 INTRODUCTION

This maintenance manual is to be read in conjunction with the Transnet Freight Rail's "*MANUAL FOR TRACK MAINTENANCE* (Latest edition)". Maintenance procedures in this manual shall takes precedence over the "*MANUAL FOR TRACK MAINTENANCE* (Latest edition)" for the TMT system.

This document is intended to cover the required inspection and maintenance procedures of *TUBULAR MODULAR TRACK* (TMT) system which are not detailed or indicated in the Transnet Freight Rail's "*MANUAL FOR TRACK MAINTENANCE* (Latest edition)".

This maintenance manual for TMT does not specify the geometry standards of the rail track, as this would be according to the Railway Authorities specification as indicated in Transnet Freight Rail's "*MANUAL FOR TRACK MAINTENANCE* (Latest edition)"

The design characteristics and performance of TMT is of such a nature that any misalignment, movement, settlement or any other non-conforming track geometry is easily identified. These parameters are measured with the standard procedures and measuring equipment as for conventional ballasted track.

It is incumbent on the Railway Authority or the Operators of any TMT system to inspect the rail track on a regular basis (at least 4 times per year) and to record these inspections.

It must be noted that when inspecting TMT, it is imperative to take the formation and drainage into consideration. TMT is an engineered system which incorporates the elastic formation, filler grout, modular beam, resilient pad, fasteners, rail and associated drainage systems.

As stated above, this maintenance manual must be read in conjunction with the relevant sections in the TFR "MANUAL FOR TRACK MAINTENANCE (Latest edition)". TMT is installed in the same rail networks as ballasted track and is therefore subject to the same specifications in so far as track geometry and maintenance of the rail and fasteners are concerned.

Deviations from the TFR "Manual for Track Maintenance (Latest edition)" are described in this document and will be applicable to TMT track only. These deviations are approved by the system designers – Tubular Track (Pty) Ltd.

2 OBJECTIVES OF TRACK MAINTENANCE

“To ensure that railway lines and associated works are always maintained to a standard that is safe for the passage of trains”

To achieve this, track personnel and employees must take the following into consideration:

- Always regard the safety of the public, goods in transit and the safety and health of other employees to be of paramount importance
- Do not expose themselves to danger and prevent other employees from exposing themselves to danger
- Continually strive for improved productivity to ensure an effective and efficiently maintained rail network.

3 TMT TERMINOLOGY AND DEFINITIONS

Abbreviations and terminologies with their definitions as use with the TMT system.

Table 1: Terminology and Abbreviations

Terminology or Abbreviation	**Definition**
Beam	The pre-cast reinforced concrete beam
CBT	Conventional Ballasted Track Rail track consisted of rails, sleeper with its rail fastening system and ballast on a formation.
Conduit	Cast in plastic pipe in beams to accommodate any form of cable, fibre optic or other applicable service
Component	Gauge Bar or Stirrup
CWR	Continuous Welded Rails
Duplex Coating	The dual process used to protect galvanised steel gauge bars and stirrups against corrosion in extreme corrosive conditions
Fibre	The polypropylene fibre that is added to the filler grout layer to reduce plastic shrinkage and cracking
Filler Grout	The fibre reinforced grout the fills the gap between the beams and the sub-ballast layer of the formation
FM	Fineness Modulus
Galvanising	The process of applying a protective zinc coating to steel or iron to protect all TMT steel components against corrosion
Gauge Bar	A steel component that ties the two pre-cast beams together and fixes the gauge of the track. Its other purpose is to affix the rail to the pre-cast beam
GPI's	Gauge Plate Insulators
Module	The combination of two beams held together with two or more gauge bars and having nominal lengths of 5 or 6 meters
Mould	The re-usable shutter which is used to manufacture the module
Resilient pad	The continuous pad that is inserted between the rail and the concrete beam to offer resilience to the track system
SANS	South African National Standards

Slack	Vertical deviation of the track profile or top over a short distance
Stirrup	A steel component that surrounds the beam and affixes the rail to the beam
Stray current lug	Section of steel wire attached to embedded reinforcing and protrudes from the ends of all modules used to connect reinforcing together
TFR	Transnet Freight Rail
TMT	Tubular Modular Track
Transition	Interface area between ballasted track and TMT or between via-duct, bridge, tunnel and TMT
Tubular Bag	A geo-textile fabric (normally green in colour) in which the pre-cast grout beams are cast

For a typical TMT cross section refer to ANNEXURE 2 – Typical TMT Installation Section.

Note: Not all modules will necessary be equipped with either a conduit or stray current lugs

3.1 Module Identification (post 2016)

The TMT Modulus type can be identified with the imprints on the top near the centre with of the beam the following markings:

X X – T – M M - Y Y – Z Z Z Z

Where:

X X - Indicates manufacturer mould number e.g. 0 1
T - Indicates track type / axle load e.g. H = 26T, P = 20T and F = 22T
M M - Indicates month of manufacturing e.g. 11 for November
Y Y - Indicates Year of casting e.g. 14 for 2014
Z Z Z Z - Indicates Tangent or Curved module e.g. R200, R450 and no marking indicate Straight or Tangent module.

3.2 Curves and Transition Curves

Depending on the project size, not all curve modules are manufactured to the exact specific curve radii, but to nominal curve radii and to accommodate the curve radii to within the A-standard of the geometry horizontal alignment requirement of:

$$A - std: 5\% * H + 2.5mm$$

Table 2 shows the manufactured nominal radius modules and their minimum and maximum curve radiuses for which it can be used.

Table 2: Curve spread for the various nominal curve radius modules

Curve Radius R (m)	Mid Ordinate H (mm) – 10m	Curve Radius Spread (m)		
		R_{min}	$R_{nominal}$	R_{max}
150*	83.3	140	150	165
175*	71.4	160	175	190
200	62.5	185	200	220
250	50.0	225	250	280
300	41.7	270	300	335
375	33.3	335	375	430
450	27.8	395	450	525
600	20.8	515	600	725
750	16.7	625	750	940
1000	12.5	800	1000	1335
TAN	0	-	-	-

* Shorter modules required

The transition curve layout is done by gradually sharpening the radius of the transition to the radius of the circular curve section. Therefore the 10m mid-ordinate of the alignment is used at 5m intervals over the 60 or 80m transition length, whereby the curve radius at the point is calculated at that chainage and the radius module that can be use within the curve radius limits is placed at that position.

See Annexure 12 for the detail on module layout of the transition curves for different curve radii and length.

4 INSPECTIONS

Regular inspections of the track are necessary for early identification of deviations from geometrical track standards. Appropriate remedial action or further monitoring on a regular basis is necessary until such time that the track can be brought to back to a safe operating standard. Inspections must also include the monitoring of formation and drainage conditions.

Planned inspections of TMT, including the frequency thereof and the types of inspections are done on the same principles and guidelines as specified for ballasted track in the TFR "MANUAL FOR TRACK MAINTENANCE (Latest edition)".

Due to the design characteristics of TMT, track geometry is generally very stable which greatly reduces the amount of maintenance required to keep the system at a safe standard. During any prescribed or planned inspections, the following items must be incorporated into the inspection over and above the items prescribed in TFR's "MANUAL FOR TRACK MAINTENANCE (Latest edition)":

- Condition of galvanising on components as this can lead to corrosion of the components, particularly in coastal areas
- Inspect steel components for any cracks or broken components
- Cracked or broken welds on components
- Position/seating of the continuous resilient pad. The pad should be correctly positioned under the rail and evidence of creeping should be noted and reported
- General condition of modular beams, damage or cracks in the beams or dislodged concrete pieces from the beam
- Rail creep - Corresponding markings on the beams and the rail can be introduced to monitor creep, particularly in areas where steep gradients are prevalent
- Any visible lateral movement of the system on the formation
- Grout - missing or crush grout that are moving out underneath the beam and voids between the beam and formation
- Formation – evidence of fines being pumped out of the formation layer material and/or the grout layer has punched into the formation

The movement of system, between the beam and grout and grout and formation, will only be observed when a train is passing over the area. Therefore, the track geometry measurements, especially the vertical alignment (top) will identify these locations for a more in-depth inspection or from geometry measuring vehicle results.

There are two possible types of movements that could occur, firstly, movement between the beam and the filler grout with will indicate a small gap and secondly movement between the filler grout and formation which will be a larger gap.

- *Movement between the beam and the filler grout interface.* This can be ascertained by careful visual inspection of the contact interface between the beam and the filler grout at the lower part of the beam. If movement is occurring, evidence of this will most likely be “white grout powder” being formed or in more severe cases, localised cracking and disintegration of the grout filler layer. Note: Not all cracks in the filler grout are an indication of failure – plastic shrinkage cracking also occurs and is not critical.
- *Movement between the filler grout and the top of formation.* In most cases this would be due to settlement of the formation, or more severely, formation failure depending on the amount of settlement. Evidence of this will be localised cracks in the filler grout layer and/or a visible gap between filler grout and formation. Further evidence of this can also be very fine material collecting along the edge of the filler grout and the formation when pumping takes place, particularly when the formation is wet.

Should any of the above scenarios become evident during inspections, the problem must be rectified immediately or be monitored depending on severity until such time that the problem can be rectified. In severe cases, Tubular Track (Pty) Ltd must also be notified for advice on corrective action/procedures.

5 MAINTENANCE PROCEDURES

Maintenance of TMT is limited and requires planned maintenance only when there is an identified non-conformity to the standards. The following is a list of possible reasons for planned and/or general maintenance to bring the rail track back to the required geometry standard.

5.1 Track Geometry – vertical (slacks)

Vertical geometry or “top, twist and cant” defects of the rail track are generally as a result of any of the following:

- Formation settlement/failure
- Filler grout failure
- Beam failure

5.1.1 Settlement in the Formation

Should it be determined that a slack in the track is outside the geometry standard and is caused by formation layer works settlement or in-situ or sub-grade material, the following procedure should be followed to bring the track back to standard. It will be noted that the constructed filler grout generally remains attached to the underside of the beam and moves with the beam causing a void or gap between the filler grout and formation material:

- Depending on the severity of the slack, the rail vertical level generally returns back too standard once the train has passed over (blind slacks only visible when a train is passing). In this instance it is not required to jack the beam back to its original position before introducing grout.
- Should the slack be permanent in nature, it will be necessary to jack the beam up to the required level. Jacks must only be inserted at component positions (on steel). Timber wedges can be inserted to keep the rail in position before jacks are removed. Alternatively, custom made spreader beams can be used that clip into the underside of the inside rail crowns. Two jacks are inserted

below the spreader beams on the outside of the TMT modules and the spreader beam is jacked up.

- At the beam/filler horizontal grout interface, drill at least a 20mm diameter hole vertically down through the filler grout, between the outer edge of the filler grout and the edge of the beam. This hole must be drilled through the filler grout layer and must penetrate the formation to ensure that the gap between the underside of the beam and the formation is intercepted. Holes can be drilled at approximately 1-meter spacing or as required. Holes can be drilled from the inside of the beams or on the field side whichever is more convenient. Should the gap (after lifting) between the filler grout and the formation be greater than 5mm, this gap can be sealed with wet paper to contain the grout (use wet cement bag paper).
- Wet all holes with water prior to introducing the grout. Insert the grout pipe into the drilled hole and pump in grout. Stop pumping when grout escapes below the filler layer or when the system becomes pressurised and no grout escapes. Continue to the next hole and repeat procedure.
- Should the gap after formation settlement be bigger than 10mm holes do not need to be drilled as explained above. The grout hose can be inserted from the side (inside or field side of the beam) directly into the gap. Ensure that all loose material is removed from the gap before introducing grout. The gap on the edges can once again be sealed with wet cement bag paper or with wet sand.
- The working time with the grout as specified is 30 to 45 minutes. It is therefore recommended to drill the holes required prior to mixing the grout. All tools and equipment and in particular the pump must be washed thoroughly with clean water after pumping is complete.
- Allow grout to cure and harden for at least 4 hours before allowing trains to pass.

Refer ANNEXURE 3 – TMT Filler Grout Repair
Refer ANNEXURE 4 – Equipment & Tools Requirement
Refer ANNEXURE 6 – RAM Grout Mix Proportion
Refer ANNEXURE 11 – Lifting of Module with Spreader Bar

When more occupation time is available, during a shutdown period, then the grout can be replace with a 15 MPa, 9.5mm aggregate and rapid hardening cement concrete mixture. Time after the “grouting” process would be at least 24 to 48 hours before opening of the track for traffic.

5.1.2 Filler Grout Maintenance

Filler grout failure under the beams will be very visible. The grout layer will have numerous concentrated cracks and will appear to be disintegrating. Pieces of grout will become dislodged from the main layer and movement of the beam will be very noticeable as trains pass over and this movement will take place within the filler layer zone. If left unattended, the disintegration of the grout will advance rapidly depending on traffic density.

Formation settlement can also contribute to filler grout degradation and ultimate failure over time. It is therefore important to identify excessive movement early, during inspections, so that the corrective maintenance can be carried out.

It must be noted that cracks in the filler grout layer do not necessarily indicate grout failure. The filler layer is a high water content product and therefore shrinkage does occur naturally after placement which results in intermittent cracking of the grout. It is therefore important to differentiate between grout failure and shrinkage cracks.

The grout sections that are visible on the outside of the beams are as a result of the shutters being spaced at approximately 50 to 80mm away from the beam during the construction group pumping process. In some instances, these sections shear off and would suggest grout failure. These sections do not carry any load and are therefore excess grout. If sections of the track display these broken areas, remove them and inspect the grout beneath the beam from the sides to ensure that the grout below the beam is in place and sound.

Should it be evident that slacks have developed as a result of filler grout failure, one of the following procedures can be followed:

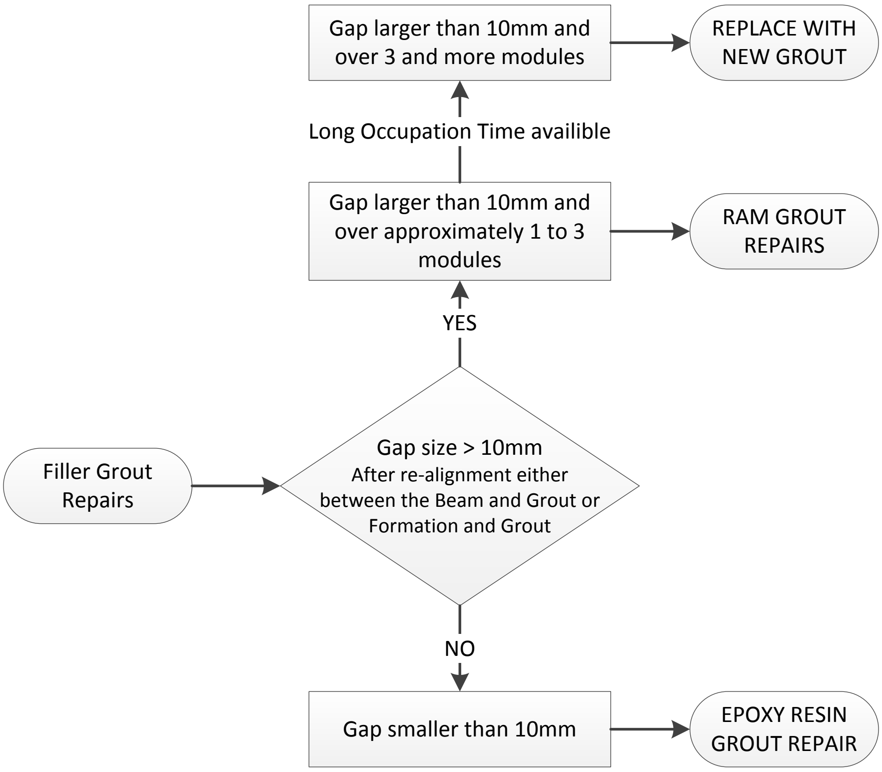


Figure 1: Filler grout repair method to follow

5.1.2.1 Ram Grout Repairs

i. Identify the length of the failure along the underside of the beam/beams. If identified early on, the extent of the failure will not be excessive (2 to 3 meters) allowing maintenance to be done in a short time.

ii. Remove the existing filler grout from the underside of the beam. Ensure that all the loose grout is removed by also removing some of the sound grout for about 200mm on either side of the failed section.

iii. If necessary, jack and support the beam at the required level.

iv. Determine which side of the beam the replacement grout is to be introduced. On the opposite side, install a removable shutter (timber of steel) against the beam and keep in position by inserting steel spikes (10mm) into the formation.

v. Insert ram grout in small quantities into the gap under the beam and compact with beta picks or other ramming devices. Keep feeding the grout into the gap and continue ramming until the entire gap is filled

vi. Refer to Annexure 6 for a Typical Mix Proportions of Ram Grout

vii. Allow to cure for 3 to 4 hours and remove shutters. Inspect to ensure that the ram grout has filled the gap and has fully come into contact with the shutter.

viii. Allow trains to pass.

5.1.2.2 Epoxy Resin Grout Repairs

i. In instances where gaps greater than 1mm have developed between the beam and the filler grout, a two-part chemical epoxy resin grout must be used to fill the gaps.

ii. The gaps develop due to shrinkage of the filler grout, or, in occasional instances, where the beam has formed a depression in the filler grout when the line has been opened for traffic before the filler grout has cured sufficiently.

iii. Once the epoxy grout has been prepared (as indicated by the supplier, manufacturer), simply pour the grout against the side of the beam directly above (50mm) the affected area. The grout will run down the beam and filter into the openings.

iv. Refer to setting times supplied by the manufacturer. Setting times are generally in the order of 45 to 90 minutes. The line can be opened once the grout has set.

v. Refer to Annexure 7 for suggested Epoxy Resin Grouts

5.1.3 Module Replacement

In extreme instances, a beam or a series beams or modules could fail. This is highly unlikely and such failures would generally be as a result of a derailment or some form of rolling stock failure.

If the beam is damaged to such an extent that the rebar is exposed together with disintegration of the grout, the module will need to be replaced.

Should the beam show signs of cracking and the rebar is not exposed, or only partially exposed and the components are still intact and "working" (even damaged), the integrity of the module could still be intact and will not require immediate replacement. This can only be determined from a detailed inspection. Trains can still pass with a speed restriction, if necessary, and the module can be replaced at a later stage on a planned occupation.

The following procedure shall be followed to replace a module:

- Loosen the rail on the damaged module/s including 2 modules on either side of the damaged module. Insert wedges under the rails on the undamaged modules either side to lift and position the rails at least 50mm above the top of the module.
- Break the filler grout at the ends of the damaged module. This can be done with a chisel and hammer or, if available, with and electric angle grinder or pneumatic jack-hammer.
- Tie the resilient pad to the underside of the elevated rail or cut it at the module joints and keep for later re-use.
- Attach slings to the module and pull it out to the side (horizontally) using crane truck, FEL, TLB, Bobcat, etc.
- Remove any filler grout on the formation that may have been left behind and clean formation.
- Place the new module as close to the final position as possible and pull into position using slings.
- Place the resilient rail pad on top of the new module. Lower and fasten the rails onto the new module (remove wedges). Align the module using pinch bars and jacks into position. Insert wedges (timber or other) under the module to keep in position.
- Measure and check final alignment and adjust if and where required. Mix ram grout and insert as described in section 5.1.2.1.

5.1.4 Occupation Time Requirements

For the different grouting processes the table below shows the required occupational time requirements, but the time will depend on the severity of the problem, as well as the prevailing weather condition at the time of the occupations.

Table 3: Occupation times and working Temperatures

Occupation Time	Temperature	Work Extent Modules	Grout Method
24 Hours	+ 15 °C	> 10	Normal Grout
	< 15 °C	5 – 10	Ram Grout
8 Hours	> 5 °C	3 – 5	Ram Grout
	< 5 °C	2 – 3	Special grouts (Sika & Mapei)
4 Hours	> 15 °C	2 – 3	Epoxy Resin Grout
			Concrete replacement

5.2 Component Maintenance

Damage can occur to components (stirrups and gauge bars) due to the following factors:

- Fatigue of the components
- High lateral forces
- Rolling stock failures
- Derailments
- Corrosion

Components must be inspected, and the damage ascertained to determine if they require replacement or alternative repair on site.

If premature failures are taking place the cause of such failures must reported and investigated and corrective measures or system improvements to be made.

The following is a list of maintenance or repair procedures:

- Corrosion of TMT Components
- Damaged Components

5.2.1 Corrosion of TMT Components

All steel (excl. reinforcing) components are hot dip galvanized to SANS Standards. There are, however, occasions where this protection is compromised. The components need to be out in the field for a length of time before oxidization becomes evident and corrosion can be identified.

The following procedure should be followed to repair corrosion of components:

- Identify the area or areas that need to be treated
- Use of a wire brush to remove all indications of oxidization (rust), flakiness, etc.
- Remove all signs of oil and grease using a rag soaked in thinners
- Apply Cold Galvanizing as per manufacturer's specification in either "spray on" or "paint on" application.

5.2.2 Damaged Components

Components are visible and include the gauge bars and stirrups. Affixed to these components are the weld-on fastening shoulders. Repairs to these components can be made on site in the track.

Damage to components and the TMT system in general is caused by external factors such as rolling stock failures and in severe cases, derailments. Depending on the extent of the damage, components can be repaired, or in more severe instances, be replaced without replacing the module.

This section deals only with the repair or replacement of components and does not include any running repairs to, or the replacement of modules. It is however imperative that, in all cases, the beams be inspected closely in the vicinity of damaged components as there may be damage to the beams that is not evident on initial inspection.

5.2.2.1 Inspection Procedure of Damaged Components

In the event of a damaged gauge bar or stirrups, the following inspection procedure must be followed:

a. Identify the damaged gauge bar/s
b. Check the rail gauge at the gauge bar/s
c. Inspect the gauge bar and determine the extent of the damage to the component. Inspect the following:

i. Any indication of tearing of the steel
ii. Any indication of tearing/failure of welds
iii. Signs of tie bar deformation

d. Inspect the shoulders and fasteners for damage.

If, after inspection as described above, the rail gauge is within tolerances, it will not be necessary to replace the gauge bar.

If the track gauge be out of tolerance, the following procedure should be followed:

5.2.2.2 Gauge Bar Replacement (Tie bar section only)

a. Cut the tie bar (IPE section) off from the two stirrups (hoops) using an electrical angle grinder. Care should be taken to protect the geo-textile tubular bag against heat and sparks by using a heat cloth.

b. Grind the area on the hoops where the tie bar was attached and remove galvanizing in the immediate vicinity.

c. Check rail gauge:

i. *Narrow gauge*: Insert a rail jack between the two beams and jack the two beams apart until gauge is back to standard. Insert replacement IPE tie bar and weld in position. Release jack. Remove welding slag and apply with Cold Galv (paint or spray on) as specified once welding area has cooled down sufficiently.

ii. *Wide gauge*: Inspect which beam needs to be closed and place a rail jack on the field side of the beam and jack beams together until gauge is to standard. Repeat on opposite beam if required. Insert IPE tie bar as instructed above.

Note: In some instances, depending on circumstances, the replacement IPE tie bar can be welded directly on to the two stirrups that are immediately adjacent to the damaged gauge bar. The stirrups must first be prepared by removing the galvanizing with an angle grinder where the tie bar is to be welded to the stirrups.

Refer ANNEXURE 8 – Partial Replacement of Damaged Gauge Bar

5.2.2.3 Gauge Bar Replacement

This procedure must be followed when the gauge bar is deemed to be damaged beyond "in-situ" repair.

Note: This procedure must also be used for the replacement of a stirrup or when weld-on shoulders are damaged resulting in the rail gauge being out of standard.

a. Loosen the rail 10 meters on either side of the damaged component. In the case of gauge bars, loosen rails on both beams
b. Lift the rail at least 50mm and support with wedges
c. Using an angle grinder, cut the flat bar section of the hoop around the concrete beam at a point below the IPE tie bar. Cut the hoop at the same height on the field side of the beams. Care must be taken not to cut into the concrete beam with the cutting disc.
d. Remove the damaged component
e. Insert the replacement gauge bar or stirrup and mark off the distance on the flat bar sections on the replacement component to suit the existing flat bar sections which remained under the beam/s. Trim these ends to suit. Ensure that the replacement component fits into the indentations in the beam left by the original casting
f. Weld the new gauge bar or stirrup to the existing flat bar sections taking care not to damage the tubular bag and over-heating the concrete beam by alternating the welding from inside to outside and allowing cooling between weld runs
g. Clean weld and apply "Cold Galv" as specified
h. Ensure resilient pad is in place, lower the rail and fasten.

Refer to ANNEXURE 9 – Complete Replacement of Gauge Bar and Stirrup

5.2.2.4 Temporary Gauge Straps

Standard TFR "Gauge Straps" can be used in emergency cases where damage to the system is of such a nature that running maintenance or repairs can be planned for a later date. These Gauge Straps are not to be considered as a permanent or indefinite solution. Permanent repairs or maintenance must be carried out as soon as an occupation can be arranged.

They can be used to hold the rail gauge on a temporary basis and are best used at the gaps (100mm) between the modules. If the damage is of such a nature that the entire module is intended to be replaced, slots (120mm wide x 25mm deep) can be cut into the beam to accommodate the strap. These slots can be cut using an angle grinder, hammer and chisel.

The new (post 2016) modules incorporate a recess for welding at or near the centre of the beam of 200mm wide and 30mm deep which can be utilized for the temporary gauge strap.

5.3 TRANSITION SECTION MAINTENANCE

The "transition" is the interface or change between different rail track systems or track formations for example:

- Tubular Modular Track (TMT) to Conventional Ballasted Track (CBT)
- Open track to tunnels or bridges with or not with the same track system.

Specially designed modules are used in these areas and can be either one module or a combination of modules. The transition modules can be larger in dimension or have more gauge bars or a combination of both.

In essence, any inspections or maintenance of these transition modules is the same as that for standard TMT track. The only difference is that it is not necessarily supported by the filler grout but can be supported on ballast or a combination of ballast and grout. Therefore, more regular inspections and maintenance will be required to ensure that these modules are correctly aligned and performing as intended.

The designed ballast thickness must be maintained. Soon after installation, rail traffic will cause the ballast to consolidate and settle compromising track geometry. Extra ballast will be required and tamping by beta pick or mechanical hand-held tampers will be necessary to correct geometry. After the line has been commissioned, weekly inspections will be required for the initial month of operation to inspect transition areas. Once ballast has settled and consolidated, inspections can be extended to 3 monthly intervals.

The following should be kept in mind:

- In the transition areas, sleeper spacing is closer for approximately 10 to 15m and could also include longer sleepers as part of the design. This section of track must be inspected and maintained at the same intervals as the transition modules.
- Ballast profiles must be maintained to reduce loss of ballast
- Slacks must be avoided in the transitions.

5.4 Drainage System

5.4.1 General Drainage

The drainage system along and between the TMT system should be inspected on a regular basis especially before and during the rainy season. The drainage channels and pipes as well as between the beams should be cleared of any dirt and debris during general maintenance activities.

The outside of the TMT module should be slope that water will drain outwards and would not be able for water ponding next to the track.

5.4.2 Centre Drain

The drain between the TMT module legs is known as the “centre drain”. This drain should be cleared of any dirt and debris that will prevent the water from flowing towards the outlet drainage channels.

Where the cracks are small the surface should be cleaned and a seal should be applied to prevent water to penetrate the formation. Seal could be a bitumen emulsion spray or something similar.

In the instance where this drain is lined with concrete and the concrete have large cracks that allows water to enter the formation then the affected areas should be removed and new concrete lined drain casted.

6 RAIL and PAD MAINTENANCE

General rail maintenance, inspections and replacement of the rails are covered in and are subject to the TRANSNET MANUAL FOR TRACK MAINTENANCE (Latest edition). The following section will cover deviations from the TRANSNET Manual. These deviations are revised from the standard on conventional ballasted track due to reduced stress that the rail is subject to when installed on TMT.

6.1 Closure Rails

Closure Rails can be cut into the track at any point as required. Due to the continuous rail support, joints shall be at the 100mm gap between the modules or above the recess provided approximately at the centre of the modules. Typically, closure rails could be between 6 and 12 meters in length.

In the case of a rail break that is within the length of the module, a 6m closure shall be used. Should a rail break occur at the gap between two modules, a 6m closure rail can be used and weld at the recess position at or near the centre of the beams.

6.1.1 Procedure to install closure rails

a. Cut the section of rail, containing the break, excess wear or fault, at either end or at the recess position of the module. This will effectively result in a 2.5m to 6m closure rail. Should the closure rail be required to be longer than 6 meters, cut out the damaged rail over 1.5 to 2 modules to install up to 12m closure rail. The cuts must be made in the centre of the 100mm gap between the two modules or at the recess at the centre of the module.
b. Remove the fasteners and the damaged rail
c. Cut the closure rail in and cast two aluminothermic weld joints in the specified temperature range, if possible, else distressing should be done during maintenance windows.
d. A specialised welding jig, available from Tubular Track, can be used for alignment of the rails where the rails are elevated by approximately 100mm to accommodate the jig. In this case, at least 30m of rail must be loosened either

side of the weld so that the rail can be elevated. Alternatively, the welds can be cast with the rails lying on the beams using steel wedges for alignment of the rails. (refer to Aluminothermic welding specification and Procedure, TT/QMS/104/ISO)

e. In both cases, care must be taken to protect the beam and geo-textile tubular bag from slag and heat by using heat blankets.

f. Closure rail welds shall not be closer than 2500mm from either another exothermic weld or a flash butt weld.

6.2 Skid Marks

Skid marks or wheel spin damage on the rail head surface must be treated with urgency and repaired immediately by welding and grinding or and severe cases, installing a closure rail.

Table 4 blow shows the action plan for skid–mark on the rail surface.

Table 4: Action criteria for skid-marks

DEPTH OF SKIDMARK	MAX REPAIR LEADTIME	ACTION	TRAIN MOVEMENTS
0 - 0.5mm	30 days	Weld or Grind	No Effect
0.5 - 1mm	7 Days	Weld	Restricted to 40km/h
1 - 3mm	3 Days	Weld	Restricted to 40km/h
3 - 5mm	Immediately	Weld	Restricted to 15km/h
> 5mm	Immediately	Cut out of Track & insert closure rail	Line to be closed

Rail crown weld repair shall be followed as indicated in the TFR rail welding specification.

6.3 Resilient Rail Pad

The continuous resilient pad between the rail and concrete beam modules must be inspected during routine track maintenance. The pad is generally the same width as the rail foot, therefore creeping (moving out from under the rail) of the pad will be clearly visible.

In some cases, during installation, the pad could have been installed slightly misaligned. This misalignment could be seen as creep but is not necessarily the case. A note can be made of this position in the track, and on a following inspection can be monitored to see if creep is taking place.

The fastening system must also be inspected to ensure that they have adequate clamping force to keep the rail and rail pad in its position.

Should it be required to re-align resilient pad under the rail the following procedure will be followed:

a. Remove the rail fasteners and gauge plate insulators (GPI's) along the affected area including two modules either side of this area
b. Place a track lifting jacks or similar (scissors jack) in the gap between the modules and lift rails at strategic places
c. Reposition pad to align with foot of rail. Ensure that there are no foreign objects (sand, stones, etc.) under the rail foot
d. Lower jacks and re-install GPI's and fasteners
e. In some cases, the resilient pad would have a tendency to stick to the underside of the rail. The pad can be separated from the rail by using a hack saw blade (or similar object) to carefully separate the pad from the foot of the rail. It is advisable to always have some spare (new) pad available during this maintenance in case some pad is damaged during removal.

It is recommended that a proper investigation of the rail pad is done after five years in service and samples be taken where the rail pad still visually looks good and the thickness is within 0.5mm of the original thickness for stiffness testing, otherwise the pad must be replaced after this period.

6.4 Continuous Welded Rails (CWR) and Stress Free Temperature

The welding and de-stressing of rails shall be done as per the Transnet Track Maintenance Manual (Latest edition) with respect to temperature ranges for CWR.

See Welding Specification: Aluminothermic Welding Specification TT/QMS/104/ISO for Thermit Welding.

The stress free temperature of the track can be measured with a modified A-frame that will fit onto the TMT system. The testing method and stress free temperature calculation remain the same as for conventional ballasted track. See Annexure 14 for a diagram of the A-frame for the TMT system.

The major difference is the rail is lifted by grabbing onto the rail head with a locking system from preventing the rail slipping from the A-frame hooks.

All relative safety procedures and precautions as for conventional ballasted track should be followed as well when using the A-frame.

6.5 Ultrasonic Defects

All ultrasonic defects in a rail that required joggles plates and G-clamps for protection and placed on the maintenance work schedule to be removed on ballasted track shall be dealt as emergency work on the Tubular Track system.

The following procedures could be followed after the defect is found and marked:

- The use of fishplates for the specific rail where the defect is placed in the middle of the fishplate, the required holes are drilled through the rail web and the fishplates fastened.
- The affected rail will be cut on either side of the module at the interface with the adjacent modules, a length of 6m and a closure rail will be welded into place.

6.6 Thermit Weld Protection

All thermit welds that cannot be x-rayed and declared safe during the occupation time for the welding process will be joggle by using joggle fish plates with holes. The rail is drilled on either side of the weld at the required hole distances and the joggle fish plates are fastened and the bolts torqued.

7 LEVEL CROSSINGS

When track maintenance is required over a level crossing the concrete blocks between and outside the rails may be required to be lifted and placed outside the maintenance area, either outside the rail track or a distance away on the track.

This work is done with the aid of a lifting frame with a chain block or with the use of a truck equipped with a hydraulic crane. The lifting equipment must be suitable to safely lift 400kg.

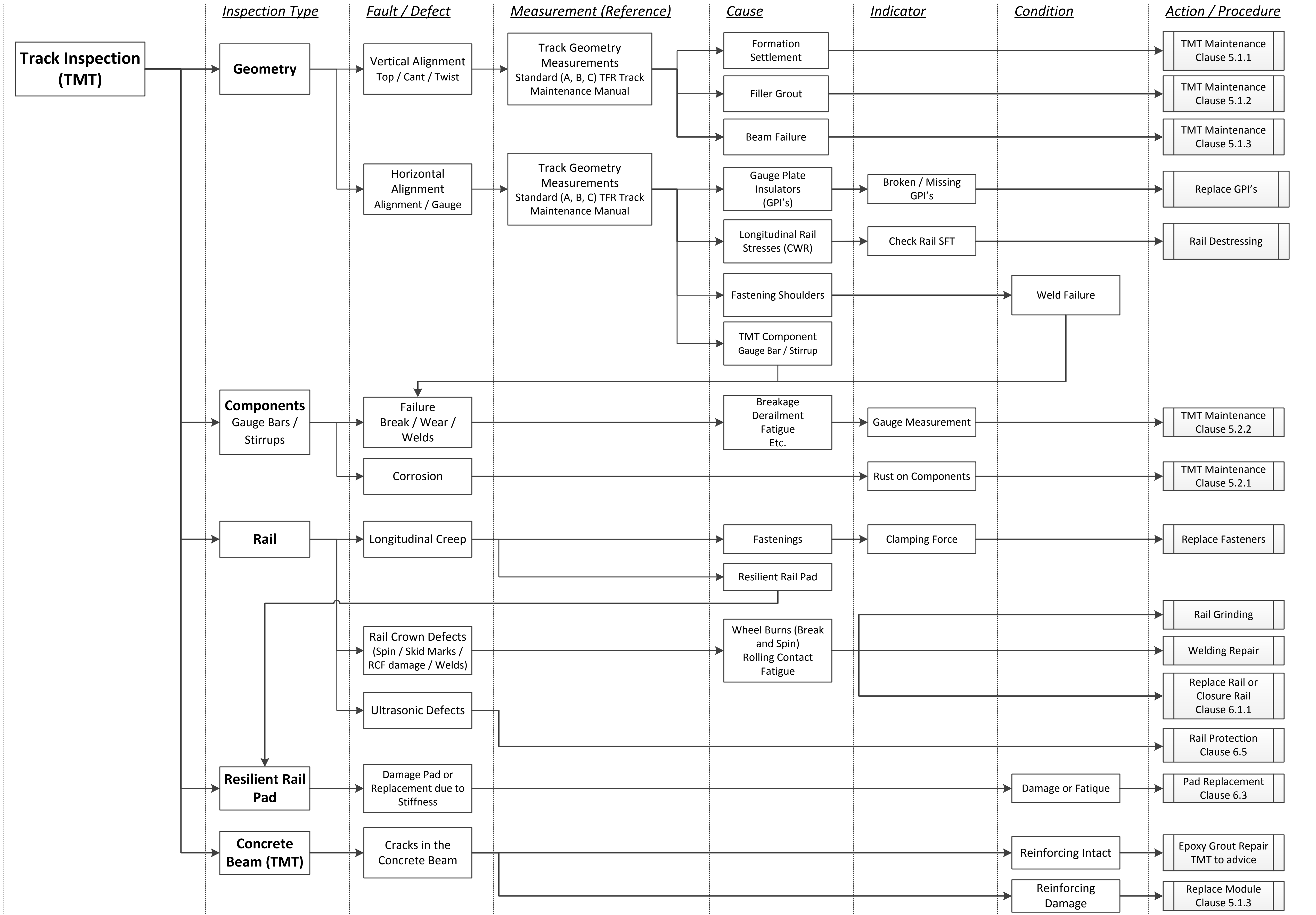
Refer to ANNEXURE 13 – Level Crossing for detail on the removal procedure of the level crossing concrete block for maintenance.

The level crossing blocks (ANNEXURE 13 – Level Crossing) for TMT consists of two (2) block types:

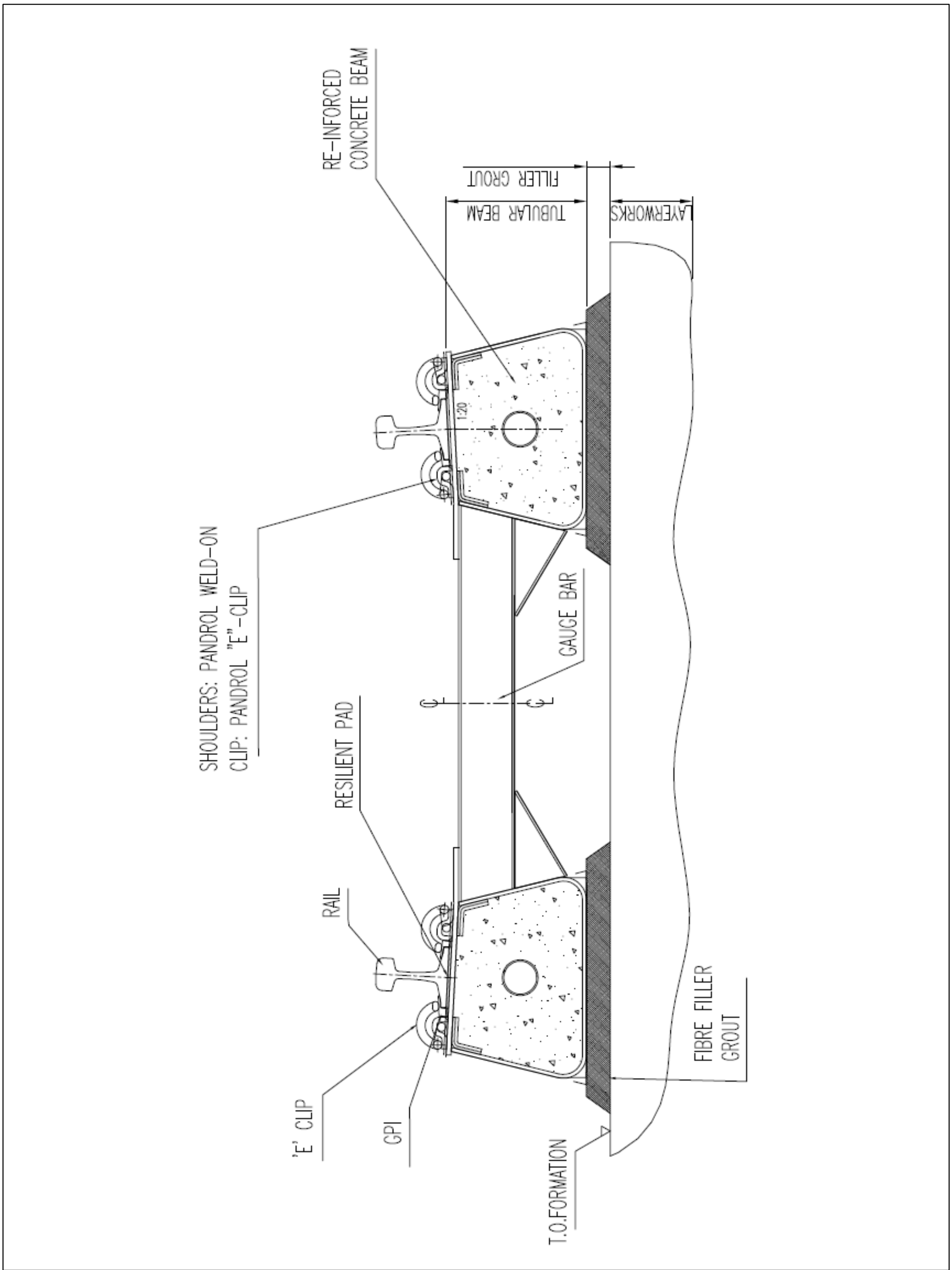
- Block Type 1 – Fits between the gauge-bars
- Block Type 2 – Fits over a gauge-bar

The concrete blocks are placed on top of a foundation block next to the TMT modules. These foundation blocks are casted into concrete during the construction of the level crossing. Ensure that all dirt and debris is cleared from these foundation blocks before the level crossing blocks are replaced after the corrective maintenance has been done.

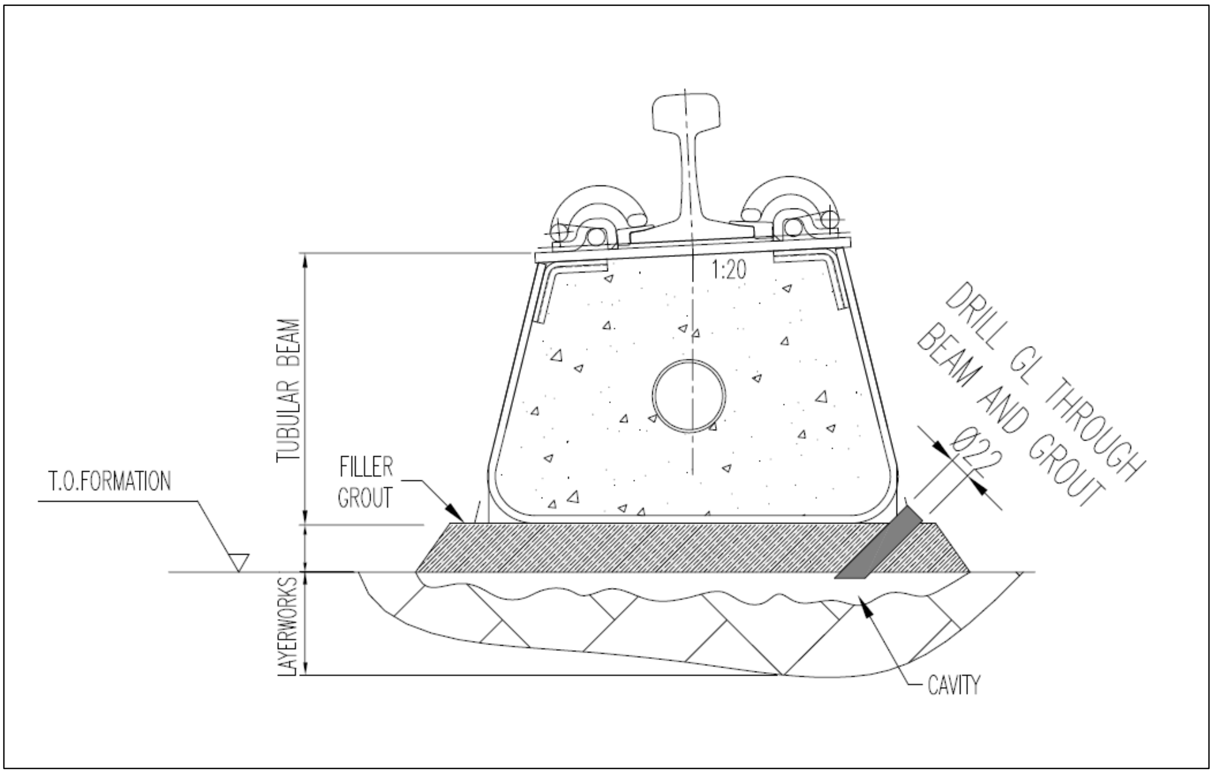
ANNEXURE 1 – TMT Maintenance Flow Diagram



ANNEXURE 2 – Typical TMT Installation Section



ANNEXURE 3 – TMT Filler Grout Repair



ANNEXURE 4 – Equipment & Tools Requirement

The following tools will be required to grout below the beam and/or between the beam and the filler grout.

It is important to have adequate water available to wash the tools, particularly the pump, after the pumping has been completed.

Item	Description	Quantity
1a	For Small Volumes Spiedel hand pump, MK 11 (available from Ictus Pumps, JHB, RSA)	1
or 1b	For Large Volumes Spiedel Air pump MKII (available from Ictus Pumps, JHB, RSA) With a 6BAR/250liter compressor – Large volumes	1
2	5 Meter long flexible hose – 25mm	1
3	20mm Pipe (outside diameter), 300mm long	1
4	5KVA Petrol Generator	1
5	220V Electric Drill with hammer action	1
6	Concrete drill bit, 22mm, min length – 200mm	1
7	Mixing drum (min 75 litres)	1
8	25 Litre water container	4
9	Flat rail trolley (optional)	1
10	Round nose shovel	2
11	Levelling Instrument (Bumpy level)	1
12	Spreader beams – (Annexure 11)	2
13	Hydraulic bottle Jacks	4

ANNEXURE 5 – Typical Filler Grout Mix Proportion

The filler grout is intended to be an extension of the formation and its purpose is to fill the gap between the top of formation and the underside of the beams.

The compressive strength of the filler grout must achieve 10MPa after 28 days and is reinforced with polypropylene fibre to reduce shrinkage.

The grout (after mixing) must have a consistency enabling it to be pumped with a peristaltic pump or similar with at least a minimum 25mm delivery outlet.

The consistency of the mix will also allow for it be gravity fed in certain instances.

Item	Description	Quantity Mass (kg)	Quantity Volume (litres)
1	Cement (OPC, CEM1, 32.5 MPa)	50	35
2	Sand (Fineness Modulus (FM) between 1.8 to 2.3)	100	150
3	Water	35	35
4	Fibre (Fibrin 23 or similar – 910 grams/m^3 grout)	0.1	To suit

ANNEXURE 6 – RAM Grout Mix Proportion

Ram Grout is a relatively dry mix of sand, cement, fibre and water and is intended to be forced into a small area by ramming the grout with a blunt hand-held object. A piece wood with dimensions 300mm x 20mm x 20mm can be used to ram.

Item	Description	Proportion
1	Cement (OPC, CEM1, 32.5 MPa)	1 part
2	Sand (Fineness Modulus (FM) in the order of 1.8 to 2.3)	3 parts
3	Water	to suit
4	Fibre (Fibrin 23 or similar – 910 grams/m^3 grout)	to suit

Note: First mix the sand, cement and fibre. While adding the water, test the consistency by taking a sample and squeeze it the hand and open and open the hand. If the sample does not crumble easily and maintains its squeezed shape, the grout is about the correct consistency.

ANNEXUTE 7 – Epoxy Resin, Additives and Special Cementitious Grouts

Epoxy Resin Grouts

The use of Epoxy Resin grouts is for small lifts or fill up to approximately 10mm and over small distances, up to 18m. The following is a list of 2-part Chemical Epoxy Grouts that can be used

Item	Description	Supplier
1	MasterFlow®400	Samson Construction, JHB, RSA

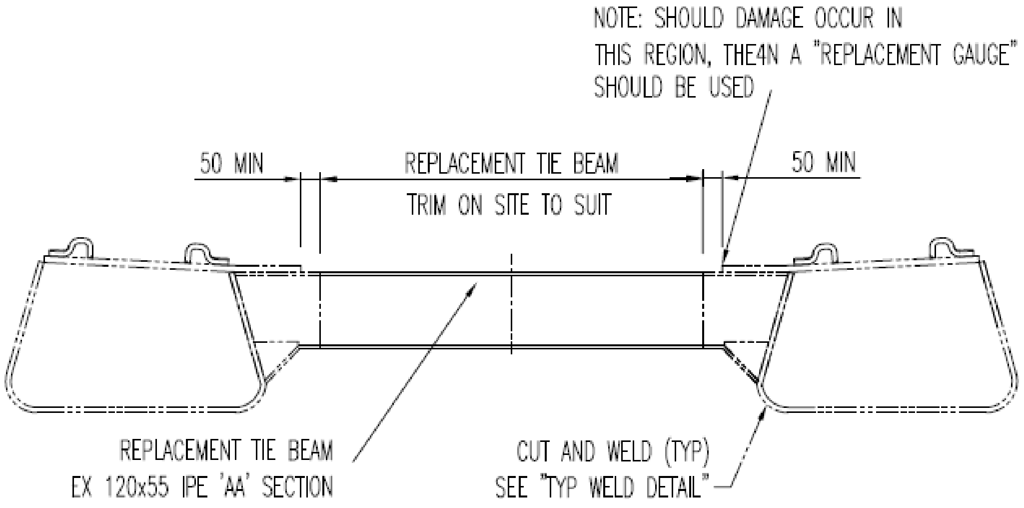
Note: Epoxy grouts must be used as indicated on the Suppliers instructions. The use of gloves and eye protection are important, always have clean water available to wash out eyes if required.

Special Cementitious Grouts

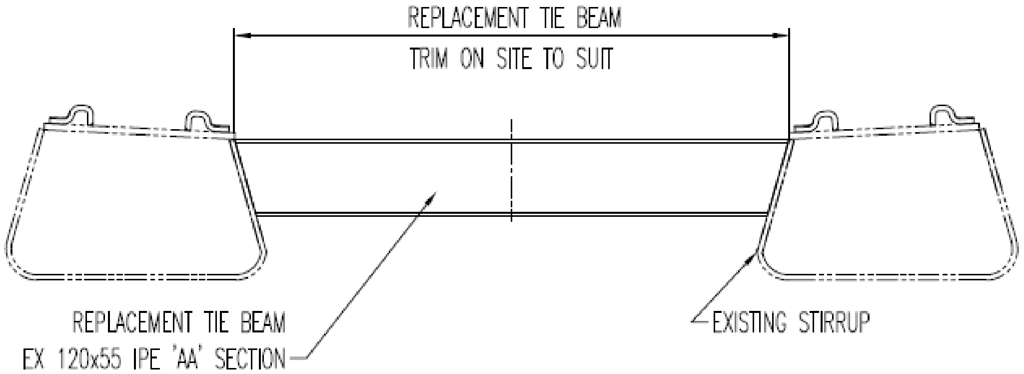
The use of “special cementitious grouts” including the use of additives for rapid hardening, shrinkage compensation, for working in cold ambient temperatures and where early strength (time limit) is required. The following is a list of *Special* Cementitious Grout products that can be used.

Item	Product Name/Number	Supplier	Function / Advantage
1	CABLEJET	Mapei	Anti-Shrinkage
2	SikaGrout ® - 212	Sika	Ready mix Rapid Strength Shrinkage compensation
3	Mapecure SRA	Mapei	Shrinkage compensation
4	MasterPozzolith 555	BASF	Rapid Strength

ANNEXURE 8 – Partial Replacement of Damaged Gauge Bar

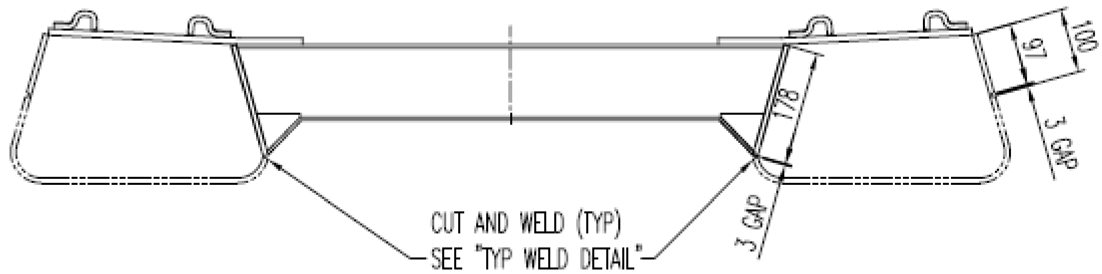


VIEW ON REPLACEMENT TIE BAR AT
EXISTING GAUGE BAR

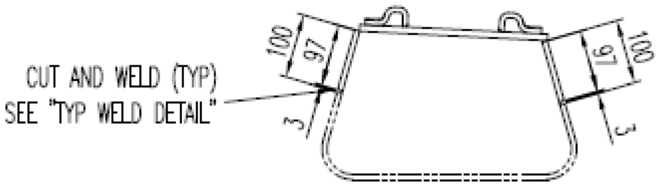


VIEW ON REPLACEMENT TIE BAR AT
EXISTING STIRRUPS

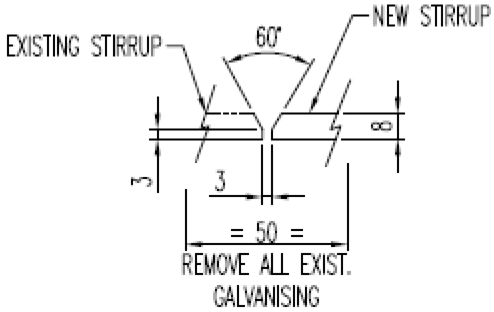
ANNEXURE 9 – Complete Replacement of Gauge Bar and Stirrup



SECTION VIEW ON REPAIR GAUGE BAR

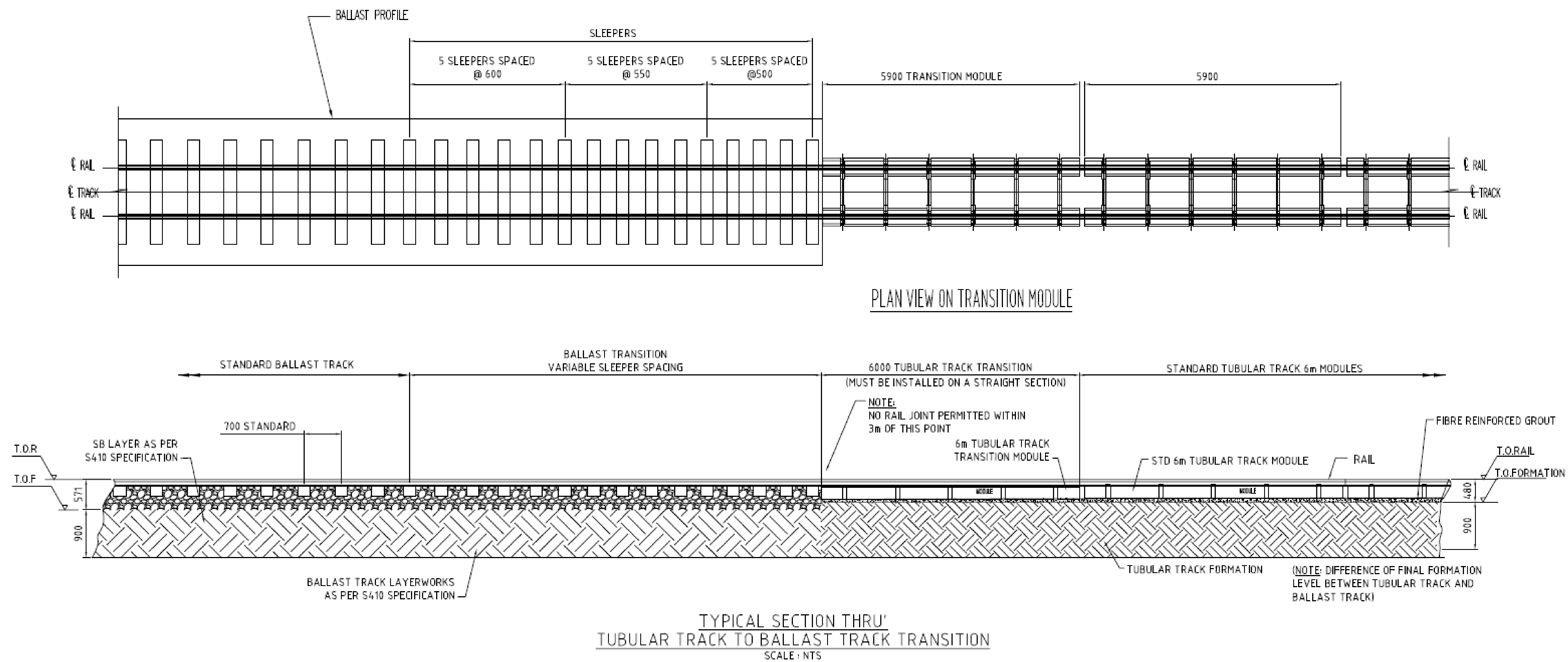


SECTION VIEW ON REPAIR STIRRUP

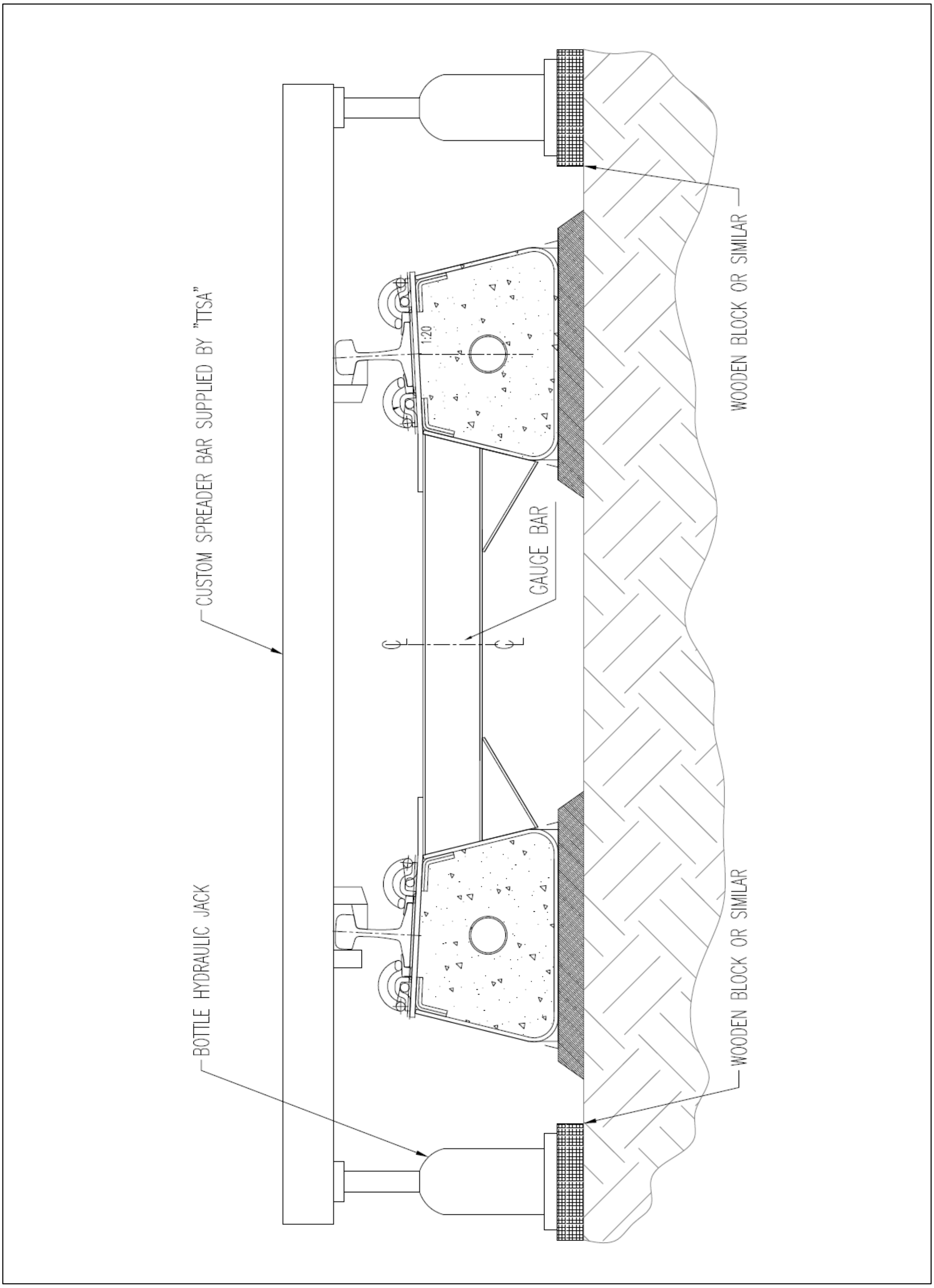


TYPICAL WELD DETAIL

ANNEXURE 10 – Typical Transition Ballast / TMT

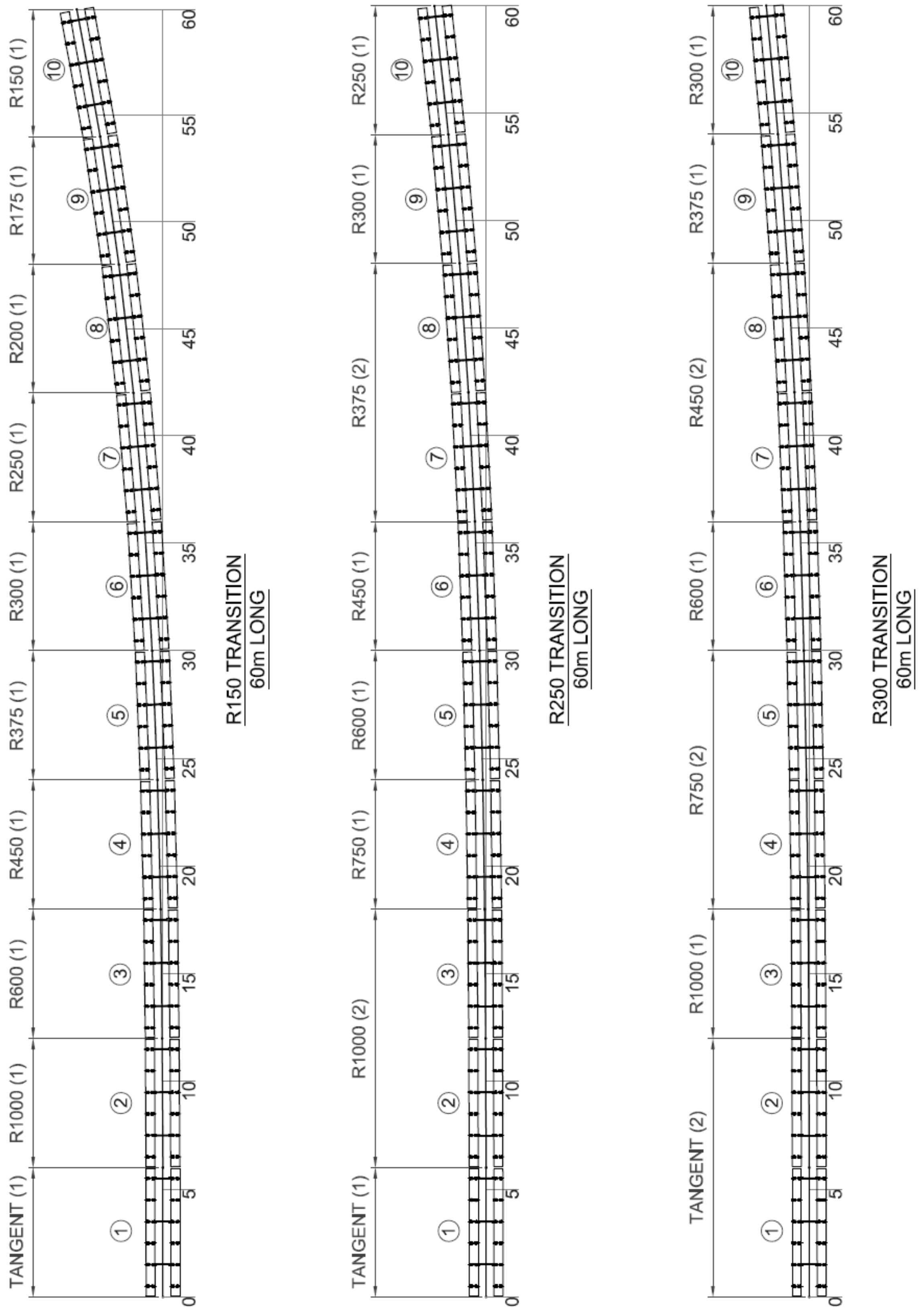


ANNEXURE 11 – Lifting of Module with Spreader Bar

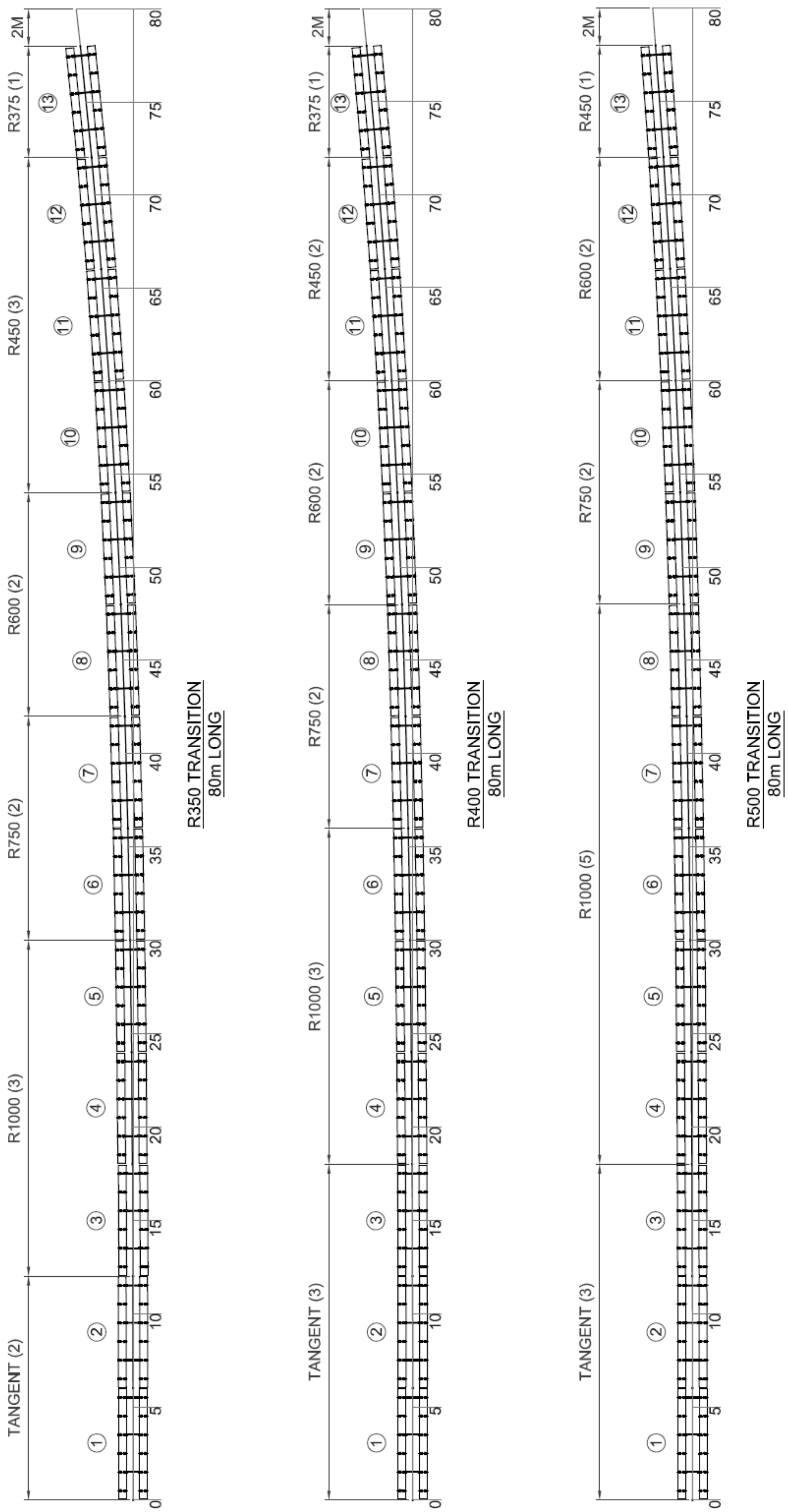


ANNEXURE 12 – Transition Curve Module Layouts

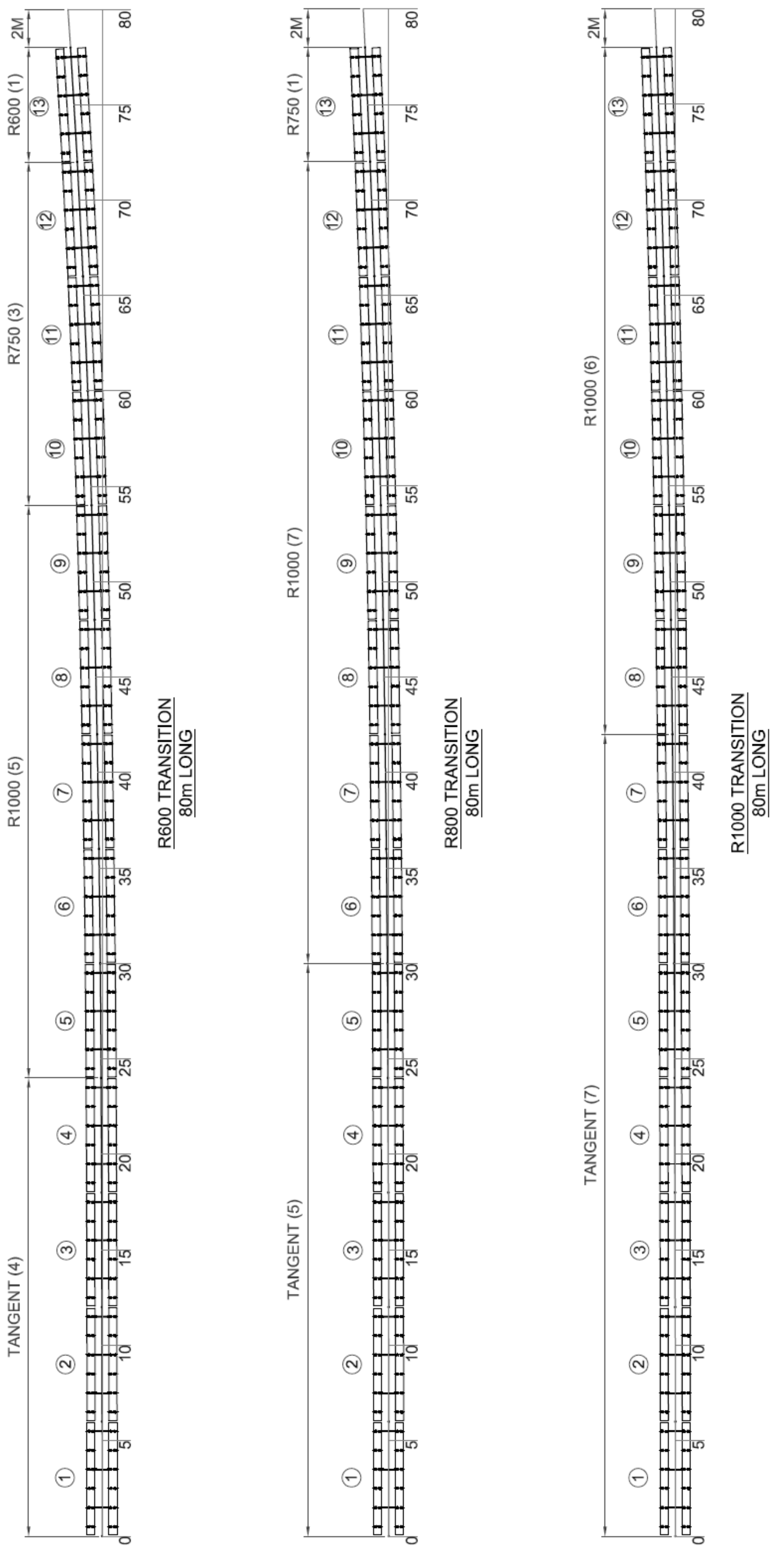
Transitions of 60m with Curves Radii smaller than 300m



Transitions of 80m for Curves Radii from > 350m to 500m

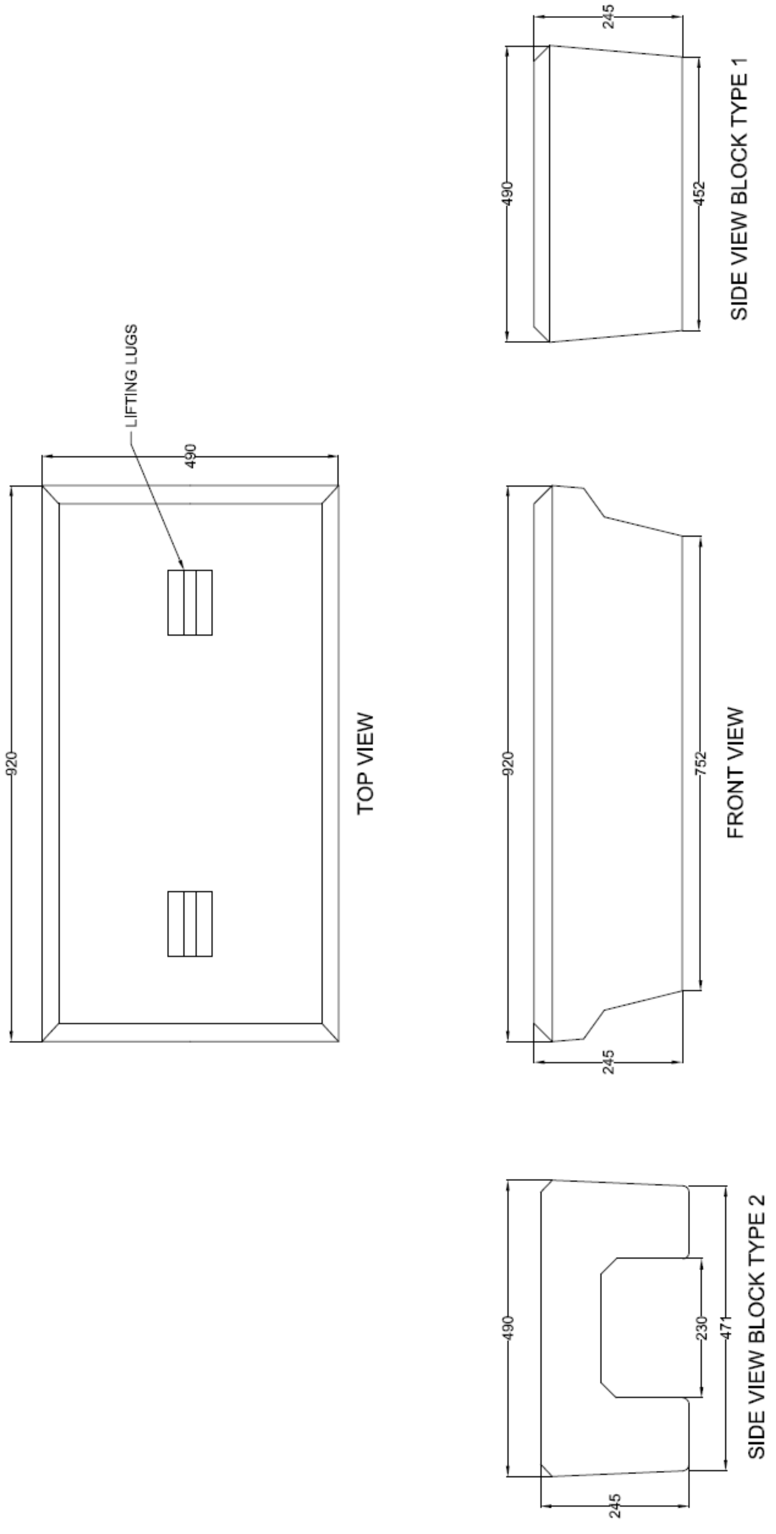


Transitions of 80m for Curves Radii bigger than 600m

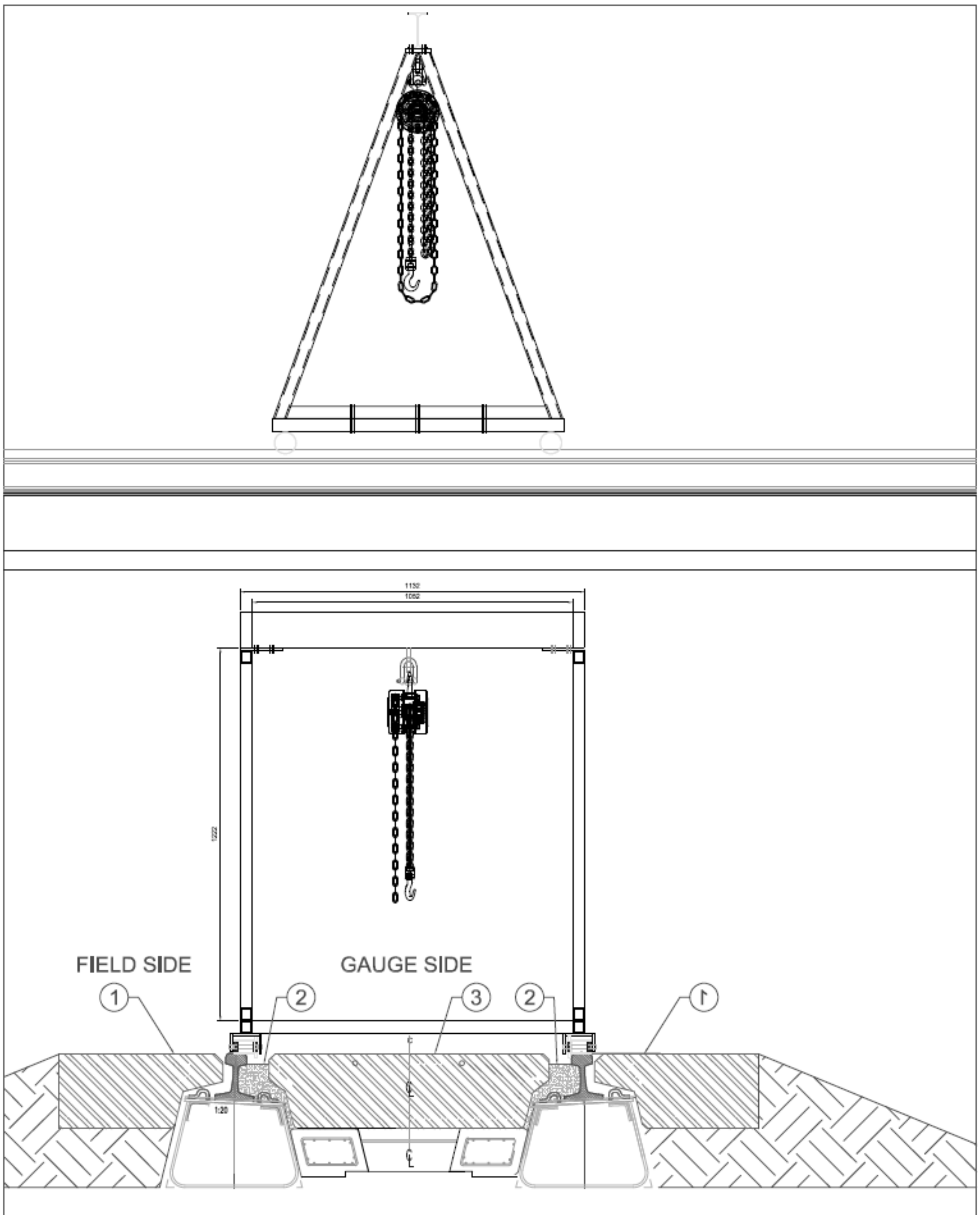


ANNEXURE 13 – Level Crossings

Level Crossing: Block Types



Lifting Frame with chain block and working procedures

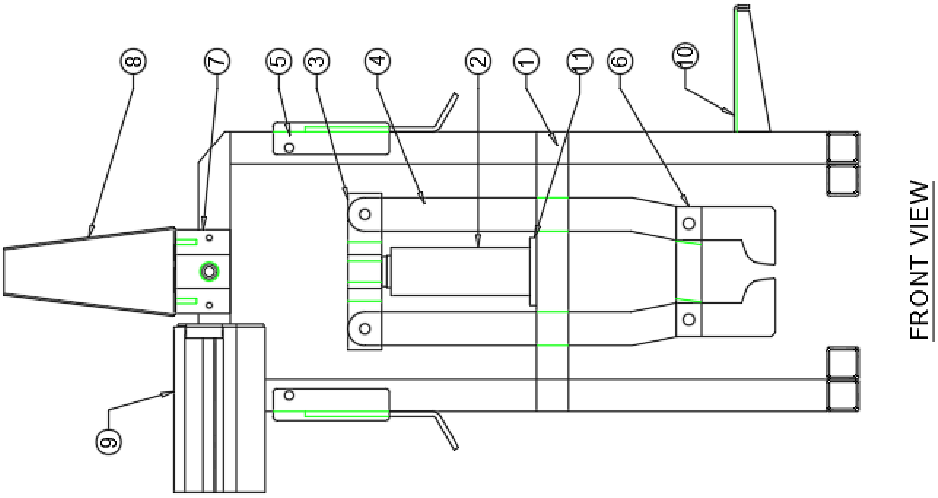


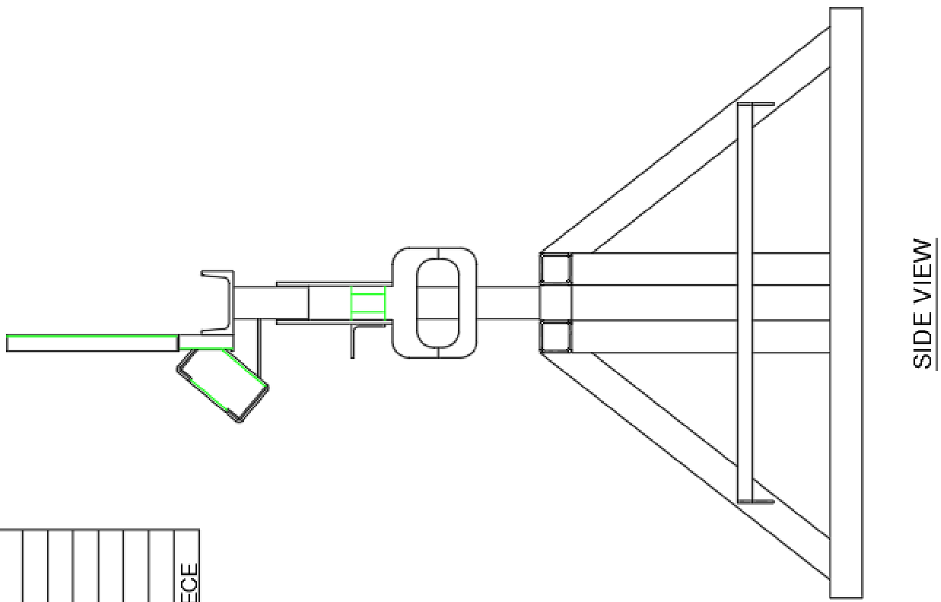
REMOVE FIELD SIDE LEVEL CROSSING BLOCK (1)
REMOVE FILLING MATERIAL BETWEEN CEMENT BLOCKS AND RAILS (2)
LIFT CENTER LEVEL CROSSING BLOCK AND PLACE OUTSIDE WORKING AREA (3)

MAKE USE OF ILLUSTRATED FRAME WITH CHAIN BLOCK
OR MAKE USE OF HYDRAULIC CRANE (TRUCK MOUNTED)

DO REQUIRED TRACK MAINTENANCE
REPLACE LEVEL CROSSING BLOCKS (RAIL SIDE)
ADD NEW FILLER MATERIAL
REPLACE LEVEL CROSSING BLOCKS (GAUGE SIDE)

ANNEXURE 14 – A-Frame





ITEM	QTY.	DESCRIPTION
1	1	FRAME
2	1	HYDRAULIC CYLINDER
3	1	LIFTING HOOK TOP PLATE
4	2	LIFTING HOOKS
5	2	HANDLES
6	1	LIFTING HOOKS LOCK
7	1	DIAL GAUGE BLOCK
8	1	VERNIER GAURD
9	1	T SCALE BOX
10	1	HYDRAULIC JACK PLATE
11	1	HYDRAULIC JACK CENTRE PIECE