GOVERNMENT OF INDIA
भारत सरकार

MINISTRY OF RAILWAYS
रेल मंत्रालय

Report on
Self Supported Roofing System

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Works Directorate
कार्य निदेशालय

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Synopsis

The roofing of a structure not only protects the structure and its interiors from the outer elements but also gives an aesthetic look to the structure. Steel roofing is generally more economical for larger spaces in terms of maintenance and enhanced flexibility of space utilization. With the invention of self-supporting structural elements as roof covering, it is now possible to develop innovative shapes of roofs especially for industrial, sports & other service buildings and public areas where long spans are desirable. Self supported structure without trusses, purlins or ancillary supports have been developed by joining several longitudinal self-supporting elements having an identical length and cross section and abutting on a rigid horizontal superstructure.

This report covers the basic concepts of self supported roofing system, installation details, advantage, disadvantage & material specifications. The report also covers cost benefit of self supported roofing system on the basis of works carried out in the past by Central Railway by providing self supported roofing system for New Station Building at LTT, CST Mumbai and Matunga Workshop.
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**Introduction:-** Self Supported Roofing system is a revolutionary system where roofing sheets do not require intermediate support like purlins or trusses. The system comprises of profiled roofing sheets that are directly fixed to the supporting structure at the sides and provide stability due to its curved shape. The shape and size of roofing element is chosen to satisfy the general requirement of strength and stiffness, lightness and economy, ease of handling and erection, proper seating and leak proof joints.

1. **ROOFING SYSTEM:-**
   - A Roof is the uppermost part of the building, provided as a structural covering, to create enclosed space for habitants and to protect from rain, sun, wind etc.
   - A Roof consists of Structural element which supports Roof Coverings.
   - The Structural element may be trusses, portals, beams, slabs (with or without beams), shells or domes.
   - The Roof Coverings may be A.C. Sheets, G.I. Sheets, Tiles or Slab Itself.
   - There are enormous varieties of Roofing Materials and their selection is done based on Price, Availability, Durability, Appearance and regional considerations.

2. **REQUIREMENT OF ROOFING MATERIAL:-**
   - It should have adequate strength and stability to carry the dead and superimposed live loads.
   - It should effectively protect the habitants and building from sun, rain, wind etc and should be durable.
   - It should be waterproof and have efficient drainage arrangement.
   - It should be fire resistant.
   - It should be aesthetically appealing.

3. **METAL ROOFING:-**
   Nowadays Metal Roofing of aluminum-zinc alloys is replacing conventional AC/GI sheets as being:
   - Fire-resistant qualities,
   - Longevity,
   - Light Weight,
   - Speed of installation,
- Low-maintenance,
- Recyclable, predictable and reliable material and quality.
- Metal roofing also lends itself well to many design elements currently used in today’s architecture. Hips, valleys, slope changes, transitions are all available to the designer.

4. **CLASSIFICATION OF METAL ROOFING:**

   - For the purposes of Spanning Ability, metal roofing can be divided broadly into two categories.
     - Non Structural Roofing
     - Structural Roofing

4.1 **NON STRUCTURAL METAL ROOFING:** Nonstructural roofing requires a continuous support or closely spaced Purlins, Channels or Trusses
4.2 STRUCTURAL METAL ROOFING :-

- Structural roofing can span the distance between the supporting roof purlins/Beam by itself, similar to metal decking.
- It is also called “Self Supported Roofing”.
- Today, structural roofing is used in many industrial and commercial applications worldwide.

5. MERITS OF SELF SUPPORTED ROOFING SYSTEM:-

- Stability is ensured based on arch principle without Truss, Purlins or intermediate supports.
- Can provide unobstructed clear span of **9 m to 30 m**.
- Roofing panels are mechanically seamed (Interlocked) and free from holes, nuts, bolt overlaps and sealants, thereby ensuring almost zero maintenance.
- Mechanical sealing ensures 100% Leak Proof Roofs.
- Faster Execution and Errection (around 1500 sq. mtrs in 12 hrs).
- No Bird nuisance and hence provides cleaner and more hygienic Building.
- Distinguished Arch Shape and Flexibility of colors result in strong aesthetic appeal.
- Upto 50% Economical compared to Conventional Roofing System.

6. MATERIAL AND TECHNOLOGY:-

- There are different type of materials for the construction of roof frame and roof covering. Common materials are metal/galvalume sheets, ferrocement, plastics and canvas.
- Most common material for roof covering is High Quality, High Grade, Pre-Coated Galvalume Sheet of Thickness 0.8 mm to 1.6 mm. Galvalume steel is the ideal material being flexible strong and corrosion proof. It is aluminum-zinc alloy-coated steel sheets with 55% aluminum, 43.5% zinc and 1.5% silicon coating.
GALVALUME is a flat rolled steel sheet coated with alloy of Aluminum, zinc and silicon, produced by a continuous hot dip process.

- It is four times more corrosion resistant than Galvanized steel in similar environmental conditions.
- Grade 550 Steel used is known as High tensile steel with a minimum tensile strength of 550 MPA.
- These sheets have less tendency of fly off when a strong wind blows unlike other commercial quality or low tensile steel.

7. SPECIFICATION OF GALVALUME SHEET:-

<table>
<thead>
<tr>
<th>BASE METAL</th>
<th>Cold Rolled Structural Quality Steel In Coil Form, Coil Width: 914 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEEL GRADE</td>
<td>GRADE D: 350 MPa Yield Strength. Min.</td>
</tr>
<tr>
<td>STEEL THICKNESS RANGE</td>
<td>0.8 mm To 1.60 mm (Base Metal Thickness)</td>
</tr>
<tr>
<td>BARE GALVALUME COATING</td>
<td>AZ 150, 150 Gms./Sq. M. Alu-Zinc-silicon Coating (55% Al. 43.5% Zn. and 1.5% silicon)</td>
</tr>
<tr>
<td>COLOUR COATING &amp; TESTING METHODS</td>
<td>Top Side – Suitable for Roll-Forming, 20 microns total dry thickness, NCCA Standard T-Bend Test method or ASTM D4 145-83 Back Side – 12 microns total dry thickness, epoxy primer and polyester wash-coat.</td>
</tr>
<tr>
<td>WEIGHT PER SQ MTR.</td>
<td>Thickness Kg/Sq Mtrs: 0.8mm 0.9mm 1.0mm 1.1mm 1.6mm Weight Kg/Sq Mtrs: 10 11.1 12.5 13.9 20</td>
</tr>
<tr>
<td>COIL WEIGHT</td>
<td>APP. 3.75 TONS (Length of sheet 400 to 450 mtrs.)</td>
</tr>
<tr>
<td>STANDARD</td>
<td>ASTM A792 :Standard Specification for Steel Sheet, 55 % Aluminum-Zinc Alloy-Coated by the Hot-Dip Process</td>
</tr>
</tbody>
</table>

Further technical details of galvalume sheet is provided in Technical data sheet as Annexure – A

8. PRIMARY SHEETING MATERIAL:-

Galvalume Sheets comes in Cold Roll Coils of width 0.914 m, length varying from 400 to 450 m, each roll weighing approx. 3.5 Tones. It is per-painted by PE-Color (Polyester Coated Aluminium) with thickness varying from 15-20 microns.
9. SYSTEMS OF SELF SUPPORTED ROOFING:

Three prominent systems are prevalent as below.

1. PROFLEX ROOFING SYSTEM
2. KALZIP SYSTEM by KALZIP LTD.
3. SAFLOK 700 by SAFINTRA LTD.

9.1 PROFLEX ROOFING SYSTEM:

Proflex Roofing Solutions Technology uses high quality, high grade, pre-coated Galvalume Steel as the basic raw material. The panel forming and installation is a complete on-site process. The Mobile panel forming Units (roll-forming/panel fabrication equipment) along with crane, seaming and other equipments are transported to project sites with required manpower, enabling panel forming & installation. The process allows high-speed operations, thereby saving time.

The steel coils of the designed width, is fed into the Mobile panel forming Units. This Mobile panel forming Unit equipment forms profiled panels having the desired finished width, length and curvature, in two stages. The installation can start from one end of the building, and moving along the length of the building, the process shall be completed. Roofing panels are installed over RCC gutter beam with Anchor bolts or with Nut Bolts in case of Steel Beams at both ends. The RCC/steel sub-structure has to be designed considering the arch reaction data with suitable load combinations.

9.1.1 FABRICATION AND PANEL FORMATION:-

- The Panel formation is done as per the required length and curvature at the site itself.
- The Sheet from the roll is passed through a Hydraulic Profile machine (MIC Machine) to give it the Trapezoidal shape and cut to the required length.
- After the profiling, these panels are passed through another Hydraulic machine for Pre Curving as per the design.

Fig: MIC Profiler machine

Fig: Trapezoidal shape panels
9.1.2 MECHANICAL SEALING:

- Seaming is like ‘zipping up’ of a rolled metal peals together using a Mechanical Seaming machine.
- Three roofing panels are mechanically seamed (Interlocked) at site along with the light fixtures and hangers.
- Panels are free from holes, nuts/bolts, overlaps and sealants which ensures almost zero maintenance.

![Mechanical Seaming Tool](image1)

![Sketch of Mechanical Seaming](image2)

9.1.3 EXECUTION AND ERECTION

- Pre Curving and assembly of Sheets are done at Site.
- The process allows High Speed Erection of Roofing Sheets giving installation speed of around 1500 sq. m. in 12 hrs.
- After Erection, it is bolted with the supporting structure by Self Splitting screws or Nuts & Bolts.

9.1.4 FIXING OF SHEETS WITH MAIN STRUCTURE

- The Pre Curved Proflex Sheet, after launching is fixed at the supporting structure or eave with self-splitting High Tensile Screws or Nuts & Bolts.
- In case of single span, side/End Support with gutters for collection and disposal of rainwater is needed.
- In case of multiple spans the center support with gutter is required.
- These supports with gutters can be RCC or Steel.
9.1.5 SUPPORT ARRANGEMENT ON RCC:

**Fig: RCC Gutter with Fixing Arrangements.**

*THIS SLOPE ANGLE IS FOR BUILDING WHERE ARCH RISE IS SPAN/5*
END SPAN BEAM
R. C. C. GUTER
MIX = (1: 1: 2)
WITH WATER PROOFING
COMPOUND
9.1.6 SUPPORT ARRANGEMENT ON STEEL:

Fig: Centre Steel Gutter with Runner Plates on both sides
9.2 KALZIP SYSTEM:-

Kalzip is precision engineered, multi component aluminum standing seam roofing and wall cladding system with adequate durability, good performance and low maintenance. It utilizes a range of materials, finishes and shapes including curved and/or tapered, and any pitch from 1.5° upwards. The system's low weight, durability, speed of construction and adaptability make it suitable for new build and refurbishment projects.

A Kalzip roof can be anything from a simple single-skin solution to a sophisticated system that incorporates integral components and accessories. Depending on the supporting structure and individual application, the roof configuration can be adapted to suit the requirements of the building, such as design, snow and wind loading, and performance targets.

9.2.1 KALZIP PROFILES:

The system incorporates a range of Kalzip aluminum standing seam profiles of different shapes and sizes.
9.2.3 KALZIP ROOF SYSTEM CONFIGURATION:-

Kalzip standing seam roof systems are available in a multitude of configurations to cater for the most of the architectural design and performance requirements.

Kalzip liner roof and Kalzip liner deck roof systems can be used for new build construction where speed of installation on a project is of utmost importance. The Kalzip structural deck and Kalzip structural cassette systems provide economical solutions for long span installations and eliminate the need for purlins.

Kalzip roof constructions can also be modified to accommodate various acoustic performance requirements, by incorporating other layers such as high density insulation, acoustic boards and flexible membranes.

To complete the chosen Kalzip system, essential components and accessories, such as clips and barrier pads, are required.

9.2.4 CLIPS & THERMAL BARRIER PADS:

Kalzip profiled sheets are secured to the substructure of a roof construction by the use of extruded Kalzip aluminium (L) clips or Kalzip E clips along with polyamide thermal barrier pads. These clip offer a fixing mechanism and the head of clip allow free movement of the external sheet during thermal cycling, enabling the use of long sheet lengths. These clips lock into the small seam of the aluminum profiles and are covered by the next profile, which is the large seam. Both these profiles are zipped to create a friction-locked connection.

Kalzip E clips are steel reinforced polyamide clips designed to further enhance the overall Kalzip system by improving its thermal, acoustic and movement performance. They offer a fixing mechanism with no significant thermal bridging whilst still retaining structural capability similar to the extruded aluminium (L) clip. The E clips also reduce the frictional forces generated during thermal cycling of the external sheet and are recommended for use on roof areas with sheet lengths exceeding 40 meters.
9.2.5 KALZIP SYSTEMS - Components and accessories

Kalzip components and accessories are specially designed to match the system components. The system consists of liners decks and cassettes. Visible elements can be added to match the individual hue/colour of the profiles or the surface of the profiled sheets to produce a harmony with the roof and wall cladding surfaces.

Kalzip deck roof                       Kalzip structural cassette

9.2.6 KALZIP FLAT ROOF

Kalzip flat roof system is a single ply membrane system which offers complete versatility across all kind of roofing applications. As an aluminum product, it combines strength with lightness, durability, corrosion-resistant and essentially maintenance-free. The design of the Kalzip system enables quick and easy installation. Roof sheets are concealed fixed to the substructure by means of non-penetrative clips.

9.2.7 KALZIP LINER ROOF:

Kalzip liners are thermally insulated roofs made of high grade steel or aluminum. Standard finishes include a galvanised, or white enamel finish to suit the internal application. The steel liner can be both smooth curved and crimp curved to suit most of the requirements. The liner can also be perforated to improve acoustic performance.

When used within the Kalzip liner roof system, the profile of the liner sheet will be determined by its dimensional compatibility with the roof sheet and its thickness will be determined by the internal wind pressure, the purlin centers, dead weight of the construction components and live load considerations.
The Kalzip structural deck roof system provides an economical solution for long span installations and eliminates the need for purlins. Kalzip structural decks are available as standard in high grade steel and zinc aluminum alloy and is suitable for rafter span ranging from 5 to 8 meters. Standard finishes include hot-dip galvanized, natural finish and white polyester coated on hot-dip galvanized substrate. Steel provides the optimum in loading and spanning capability; whereas aluminum offers exceptional durability in buildings with high humidity levels such as swimming pools.

When used within the Kalzip structural deck roof system the gauge and profile of the decking sheet is determined by the rafter centers, all external roof loads, internal wind loads, service loads and the dead weight of the construction components.
9.2.9 KALZIP STRUCTURAL CASSETTES:

Kalzip structural cassette system is suitable for wall applications. Kalzip structural trays are available as standard in high grade steel or aluminum and are suitable for long span wall applications. With structural trays, there is also a reduced requirement for structural steelwork. Once in position the interior face of the tray provides a clean and pleasing internal appearance with no visible fixings. Standard finishes include a galvanised finish or white polyester coated for a more aesthetically pleasing appearance.

When used within the Kalzip liner-deck roof system the thickness and profile of the Kalzip structural tray is determined by the purlin centers, all external roof loads, internal wind loads, the dead weight of the construction components. The system has the unique advantages of on-site production where continuous roll formed sheet lengths in excess of 150 meters are used to cover large spans.

![Structural cassette roof system](image)
9.3 SAFLOK 700:

SAFLOK 700 is an angular interlocking triple pan, 4-rib profile. It is a concealed fix sheet profile designed for very low pitched roofs. It is an angular interlocking standing seam trapezoidal rib profile, and is usually roll formed on mobile mills on the building site.

Because clips under the sheet hold it down, the sheet is not punctured with fasteners, and remains completely watertight even at a very low slope. The securing clips are pre-fixed into the purlins and the sheet is mechanically snapped onto the clip. As a concealed fix sheet can also expand and contract over the clips as the temperature changes, this system is ideal for long spans on industrial, commercial and retail buildings.

9.3.1 CLIPPING SYSTEM:-

The SAFLOK 700 clip incorporates a dual action component to positively hold down the male-female joint on every third rib, and an anchor to clasp the two inner ribs. Every rib is therefore secured, making it fully interlocking. It is essential that the male rib is directly engaged to the underside of the clip.

An Aluminum clip is a necessary when using Aluminum Material. However when using Aluminum clip on Galvalume sheets, it is recommended to use an isolation tape to prevent the bridging of the two dissimilar materials. The recommended tape is a “Denso LDP 300” or similar. Should the two metals have direct contact it will ultimately result in the manifestation of galvanic corrosion and the service life of the Aluminum will be compromised.
9.3.2 GENERAL SPECIFICATIONS:-

SAFLOK 700 can be ordered in any practical length as per customer requirements. However on site rolling is done for span lengths in excess of 13 m. The minimum roof pitch when using SAFLOK 700 is 2° on steel and 3° on wood. SAFLOK 700 is suitable for light foot traffic only with 1.5kPa downward pressure, 1.6kPa upward pressure and 0.75kPa for the side cladding, inward or outward.

The sheeting will be a double interlocking concealed fix “SAFLOK 700” profile as manufactured by Safintra Roofng, roll formed in continuous lengths from certified G550 steel or High Quality, High Grade, Pre-Coated Galvalume Sheets.

9.3.3 STANDARD INSTALLATION:-

Sheets are always laid into the prevailing weather. The first sheet is laid on the leeward (downwind) edge of the roof, with a female rib on the outermost edge.

Step 1  
Fix the first SAFLOK-700 clips perpendicular to the gutter in a straight line on the edge first sheet to ensure straightness. Care should be taken to ensure that the overlap is facing away from the prevailing weather.

Step 2  
Locate the first sheet above the clips ensuring that the overhang into the gutter is correct. Push downwards on the SAFLOK-700 sheet until the decking is secured at every clip.
Step 3
Lap the next SAFLOK-700 clip over the top of the male rib.

Step 4
The holes on the existing and new clip will align and hook into place on the self locating tabs. Fasten this section first and fix the remaining two holes as previously. Fasten all clips in this manner.

Step 5
Lay the next SAFLOK 700 sheet. Inspections should be made periodically to ensure the decking is installed squarely. This can be done by comparing the coverage at the ridge and gutter line.

Step 6
Locate the next sheet above the clips ensuring that the overhang into the gutter is correct. Proceed as from Step 2.

Note: During installation, clean the roof daily by removing all leftovers, pop rivets and unused fasteners or any other debris. NEVER re-use a Saflok 700 clip.

10. **HANGING ARRANGEMENT FOR LIGHT AND FIXURES:**

- Hanging arrangements for fixtures can be fixed during Mechanical Seaming of the panels.
- These hanging arrangements are seamed in the pre-curved panels by seaming Tool at the required Location.
- These hangers are used for hanging lights and other fixtures with maximum point load upto 25 Kg each.
PROFLEX SYSTEMS
Conceptual Layout for Light Fixture Clamp.

SECTION

ELEVATION
11. **NATURAL LIGHT:-**

- For the Natural lighting, Proflex sheet Roof is fitted with 2mm Thick transparent Poly Carbonate Sheets in the designed length and spacing.
- Fixing is done by cutting the Proflex Sheet and fixing the Flat Polycarbonate sheets.
- This arrangement makes the working area well lit during the daytime and helps saving electricity cost.

![Natural Light](image1.jpg)

12. **VENTILATION:-**

- 65cm dia Turbo Ventilators that are self-rotating, provided at top of Proflex Roof, which throws out the hot air and keeps the covered area fully ventilated.
- These ventilators do not require electricity.

![Ventilation](image2.jpg)
13. **SCHEMATIC DIAGRAM OF SELF SUPPORTED ROOF FOR PLATFORM COVERING WITH THREE TRACKS:-**

The conceptual plan of platform shelter covering three tracks using self supported profile sheets is shown in adjoining figure. The provision of turbo ventilator is made to ensure proper ventilation inside and perplex sheets has been provided to utilize day light. As proflex system is not suitable for unsupported span more than 30 m, a modified system using nominal supporting structure i.e. I-section & purlins is also suggested for spans more than 30 m. Provision of transparent solar panels at the top will not only provide day light but also generate electricity for in-house use.

Schematic diagram for electrical fitting, seating space (individual benches below the support beam & seats around the column), drainage, vending stalls, coach indication boards, signages & platform display board is also shown in adjoining figures.
PROVISION OF ROOFING SYSTEM FOR
PLATFORM AND TRACK WITH SOLAR PANEL FOR SPAN > 30 M.
CONCEPTUAL PLAN OF SEATING, DRINKING WATER BOOTHs AND VENDING STALLs
### COMPARATIVE ANALYSIS BETWEEN A.C. SHEET – MS CHANNEL, PRECOATED COLOR – MS TUBULAR, PROFLEX SYSTEMS, AND PRE-ENGINEERED STRUCTURES – FOR 15 MTRS CLEAR BUILDING SPAN.

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>POINTS OF COMPARISON</th>
<th>A.C. SHEET MS CHANNEL</th>
<th>PRECOATED COLOR MS TUBULAR</th>
<th>PROFLEX SYSTEMS</th>
<th>PREENGINEERED STRUCTURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Cost Effectiveness</td>
<td>Moderate (Rs. 4500/Sq.m approx.)</td>
<td>Moderate (Rs. 4800/Sq.m approx.)</td>
<td>Economical (Rs. 2500/Sq.m approx.)</td>
<td>Costly (Rs. 5000/Sq.m approx.)</td>
</tr>
<tr>
<td>2.</td>
<td>Fabrication &amp; Installation Speed</td>
<td>1000 sqm takes 25 to 30 days</td>
<td>1000 sqm takes 25 to 30 days</td>
<td>1000 sqm takes 1 Day</td>
<td>1000 sqm in 7 days</td>
</tr>
<tr>
<td>3.</td>
<td>Enclosed volume</td>
<td>Restrictions due to use of Trusses and Steel frames</td>
<td>Restrictions due to use of Trusses and Steel frames</td>
<td>Un obstructed clear span facilitates larger enclosed volume</td>
<td>Less obstructed as a Portal system</td>
</tr>
<tr>
<td>4.</td>
<td>Leakage and corrosion</td>
<td>Use of J-hooks and Bolts in Roofing makes it prone to leakage and corrosion</td>
<td>Use of J-hooks and Bolts in Roofing makes it prone to leakage and corrosion</td>
<td>No Punctures in Roof, therefore Leak Proof as well as Corrosion Free in short Term</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Maintenance</td>
<td>Due to leakage and corrosion, roofing and inside wall damage, need to be maintained on yearly basis.</td>
<td>Due to leakage and corrosion, roofing and inside wall damage, need to be maintained on yearly basis.</td>
<td>Being leakage and corrosion proof, structure requires little maintenances in long run</td>
<td>Required less maintenances in long run.</td>
</tr>
<tr>
<td>6.</td>
<td>Height of Structures</td>
<td>High due to use of trusses.</td>
<td>High due to use of trusses.</td>
<td>Eliminating the use of truss can reduce the overall height of structure.</td>
<td>Can reduce the height of structure by the use of portal design</td>
</tr>
<tr>
<td>SR. NO.</td>
<td>POINTS OF COMPARISON</td>
<td>A.C.SHEET MS CHANNEL</td>
<td>PRECOATED COLOR MS TUBULAR</td>
<td>PROFLEX SYSTEMS</td>
<td>PREENGINEERED STRUCTURES</td>
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<td>----------------------------------------------------------</td>
<td>------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>7.</td>
<td>Lighting &amp; Illumination</td>
<td>Obstruction in Natural and artificial lighting</td>
<td>Obstruction in Natural and artificial lighting</td>
<td>Un-obstructed Natural and artificial Lighting</td>
<td>Less obstructed Natural and artificial lighting</td>
</tr>
<tr>
<td>8.</td>
<td>Ventilation &amp; Temperature consistency</td>
<td>Temperature consistency is not good. Obstruction in clear air flow</td>
<td>Temperature consistency is not good. Obstruction in clear air flow</td>
<td>Un obstructed air flow and superior temperature consistency. Less consumption of electrical energy due to ventilation</td>
<td>Less obstructed air flow and superior Temperature consistency</td>
</tr>
<tr>
<td>9.</td>
<td>Working Environment</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Excellent</td>
<td>Comfortable</td>
</tr>
<tr>
<td>10.</td>
<td>Suitability for provision of Gantry (E.O.T.)</td>
<td>Well suited</td>
<td>Well suited</td>
<td>Well suited</td>
<td>With limitation</td>
</tr>
<tr>
<td>11.</td>
<td>Aesthetic Appearance</td>
<td>Average</td>
<td>Average</td>
<td>Aesthetically pleasing due to arch shape</td>
<td>Aesthetically pleasing</td>
</tr>
</tbody>
</table>
15. **CASE STUDIES:**

1st **CASE STUDY:** CONSTRUCTION OF NEW LTT STATION BUILDING (Span 15Mtrs, Length 150 Mtrs)

Central Railway Construction Organisation has successfully used the Self Supported Curved Metal Roofing System in Public Place at New Station Building at LTT, CST Mumbai of size 150mtrx30 Mtrs. The Span of Proflex Curved roof is 15 Mtrs (10 Spans).

**COST COMPARISON:** conventional roof with steel truss+ppgi sheet & proflex roof.

Cost of Conventional roof with Steel Truss and Pre painted GI Sheets:-

- Total Area of Roofing - 4500 Sq.Mtrs.
- Cost of Roofing with Steel Truss and Pre painted GI Sheets - Rs 6500/Sq.Mtrs.
- **Total Cost of Roofing** - Rs 2,92,50,000

Cost of Proflex Curved roof: (Span 15 Mtrs, Thickness 0.90 mm):-

- Total Area of Roofing in LTT - 4500 Sq. Mtrs.
- Total Area of Roofing with curved profile - 5033 Sq. Mtrs.
- Cost of Proflex Sheet Roofing - Rs 2304/ Sq. Mtrs
- **Cost of Proflex Roofing** - Rs 1,15,96,000

**Saving in cost:** Rs 1,76,54,000 for the area of 4500Sq Mtrs. i.e. Rs 3923 per Sq. Mtrs. (65% Saving)
IDLI Shed has been constructed with 2 Pit Lines and Gantry Girder crane in Matunga Workshop. The size of the shed is 19 Mtrs x135 Mtrs. Initially the shed was designed with Steel Truss and Pre Painted GI sheets.

**COST COMPARISON:** CONVENTIONAL ROOF WITH STEEL TRUSS + PPGI SHEET & PROFLEX ROOF.

Cost of Conventional roof with Steel Truss and Pre painted GI Sheets:-

- Total Area of Roofing - 2565 Sq.Mtrs.
- Cost of Roofing with Steel Truss and Pre painted GI Sheets
  
  Rs. 7230/Sq.Mtrs.

**Total Cost of Roofing**

- Rs. 1,85,44,850

Cost of Proflex Curved roof:  (Span 19 Mtrs, Thickness 0.90 mm):-

- Total Area of Roofing - 2565 Sq. Mtrs.
- Total Area of Roofing with curved profile - 3027 Sq. Mtrs.
- Cost of Proflex Sheet Roofing (1.2 mm) - Rs 2304/ Sq. Mtrs

**Cost of Proflex Roofing**

- Rs 69,74,200/-

**Saving in cost:** Rs 1,15,70,750/- for the area of 2565 Sq Mtrs. i.e. Rs 4511 per Sq. Mtrs. (68% **Saving**
3rd CASE STUDY: PAINT SHOP AT MATUNGA WORKSHOP (Span 25 Mtr, Length 48.8 Meters)

Paint Shop Shed of size 25 Mtrs x 48.8 Mtrs was initially designed with Steel Trusses with two spans of 12.2 Mtrs each and Pre Painted GI sheets, but later changed to single span of 24.4 Mtrs with self supported Proflex sheet roofing.

COST COMPARISON: CONVENTIONAL ROOF WITH STEEL TRUSS + PPGI SHEET & PROFLEX ROOF.

Cost of Conventional roof with Steel Truss and Pre painted GI Sheets:

- Total Area of Roofing - 1220 Sq.Mtrs.
- Cost of Roofing with Steel Truss and Pre painted GI Sheets – Rs. 5242/Sq.Mtrs.

**Total Cost of Roofing** - Rs. 63,96,250

Cost of Proflex Curved roof: (Span 25 Mtrs, Thickness 1.20 mm):

- Total Area of Roofing - 1220 Sq. Mtrs.
- Total Area of Roofing with curved profile - 1403 Sq. Mtrs.
- Cost of Proflex Sheet Roofing (1.2 mm) - Rs 2525/ Sq. Mtrs*

**Cost of Proflex Roofing** - Rs 35,42,575/-

**Saving in cost:** Rs 28,53,675/- for the area of 1220 Sq Mtrs. (span 25 m) i.e. Rs 2340 per Sq. Mtrs. (52% Saving)
16. **ADVANTAGES OF SELF SUPPORTED ROOF:-**

- Central Railway Construction organization has used Self Supported Curved Roofing System from Proflex with three different spans of 15mtrs, 19 Mtrs and 25 Mtrs successfully. Following are the distinct advantages

- Since it is a Self Supporting Roofing system Based on Arch Principle without Truss, Purlins or Ancillary support, it is very economical compared to Conventional Roofing System. The reduction in cost achieved for various spans is as under:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Span in Mtrs</th>
<th>Roofing Cost in Rs/Sq. Mtrs</th>
<th>Saving</th>
<th>% age Saving</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conventional</td>
<td>Curved Proflex</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>15</td>
<td>6500</td>
<td>2304</td>
<td>4196</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>7230</td>
<td>2304</td>
<td>4926</td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td>5242</td>
<td>2525</td>
<td>2717</td>
</tr>
</tbody>
</table>

- Faster Execution and Erection.
- The Curved Proflex roof of LTT Station Complex (4500 Sq. Mtrs) was erected in 15 Days,
- Shed at Matunga workshop (2774 Sq. Mtrs) was erected in 4 Days,
- Curved roof of paint shop (1220 Sq. Mtrs) was erected in 3 days including on-site panel formation and installation of curved Roof.
- Conventional Steel Truss roofing takes months for fabrication, erection and sheet fixing.
- It gives fully leak proof roofs.
- No Bird nuisance and hence provides cleaner and more hygienic Building.
- Distinguished Arch Shape and Flexibility of colors result in strong aesthetic appeal.

17. **RECOMMENDATION:-**

- Curved Metal Roofing system of Proflex is suitable for Workshops, Warehouses and covered public places of span varying from 9 mtrs to 35 mtrs.
- Installing Proflex Roofing system is a specialized job and can be done efficiently by the trained and skilled staff from industry.
18. **A – PIONEERS IN THE FIELD OF SELF SUPPORTED ROOFING SYSTEMS:**

1. **PROFLEX SYSTEMS**  
   Division of M&B Engineering Limited  
   MB House, Stadium Road,  
   Ahmedabad - 380014  
   Cell # +91 9099002244  
   Tel: +91 079 26405563, +91 079 26405572,  
   Fax: +91 79 2656 1588  
   E-mail: info@mbproflex.com  
   Web: http://www.mbproflex.com

2. **KALZIP LTD.**  
   Haydock Lane, Haydock  
   St. Helens  
   WA11 9TY  
   Merseyside  
   United Kingdom  
   Tel: +44 1942 295 500  
   Fax: +44 1942 295 508  
   E-mail: enquiries.uk@kalzip.com  
   Web: http://www.kalzip.com

3. **SAFINTRA Roofing (India) Limited**  
   Sultania House, 2nd Floor,  
   18 Subhash Road, Vile Parle (East),  
   Mumbai: 400057  
   Tel: +91 2242489696  
   Fax: +91 22 42489650  
   E-mail: info@safintra.in  
   Web: http://www.safintra.in
4. MERCURY ENTERPRISES Ltd.
   1, Karan Gharonda Society
   Sainikwadi, Vadgaonsherki,
   Pune - 411014

   Cell # +91 9860191038, +91 9423251936
   Tel: +91 20 27037391
   Fax: +91 20 27037391
   E-mail: mercury.roof@gmail.com

5. KAILASH ROOFING
   922, ITI Layout, Ring Road,
   Papareddypalya, Nagarabhavi 2nd Stage,
   Bangalore - 560072

   Tel: +91 80 23185345
   Fax: +91 80 23186437
   E-mail: sales@kailashroofing.com
   Web: www.kailashroofing.com
A. **CLASSIFICATION OF COVERING SHEET:** The material is available based on the type of base metal used and available in following trade names.

- Commercial steel (CS)
- Forming steel (FS)
- Drawing steel (DS)
- High temperature steel (HTS)
- Structural steel (SS)

Structural steel (SS) is available in two grades namely 340 and 550.

These products are available in several coating masses with coating designations as given below:

<table>
<thead>
<tr>
<th>Coating Designation</th>
<th>Minimum Requirements</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Triple spot</td>
<td>Single spot</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>test</td>
<td>test</td>
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<td></td>
<td></td>
<td>Total both</td>
<td>Total both</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>sides, g/m²</td>
<td>sides, g/m²</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>AZM 100</td>
<td></td>
<td>100</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AZM 110</td>
<td></td>
<td>110</td>
<td>95</td>
<td></td>
<td></td>
<td></td>
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<td>AZM 120</td>
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<td></td>
<td></td>
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<td>AZM 180</td>
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<td>180</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All coating weight tests have to be performed in accordance with the requirements stated in specification ASTM A924/A924M.

B. **CHEMICAL COMPOSITION:**

The heat analysis of the base metal shall confirm to the requirements as shown below:

<table>
<thead>
<tr>
<th>Designation</th>
<th>Composition, %—Heat Analysis Element, maximum, Unless Otherwise Shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Type A&lt;sup&gt;CD,E&lt;/sup&gt;</td>
<td>C 0.10 Mn 0.60 P 0.030 S 0.035 Al ... Cu 0.25 Ni 0.20 Cr 0.15 Mo 0.06 V 0.008 Nb 0.008 Ti 0.025 B ...</td>
</tr>
<tr>
<td>CS Type C&lt;sup&gt;D,E&lt;/sup&gt;</td>
<td>C 0.08 Mn 0.60 P 0.10 S 0.035 Al ... Cu 0.25 Ni 0.20 Cr 0.15 Mo 0.06 V 0.008 Nb 0.008 Ti 0.025 B ...</td>
</tr>
<tr>
<td>FS&lt;sup&gt;C,G&lt;/sup&gt;</td>
<td>C 0.02 to 0.10 Mn 0.50 P 0.020 S 0.030 Al ... Cu 0.25 Ni 0.20 Cr 0.15 Mo 0.06 V 0.008 Nb 0.008 Ti 0.025 B ...</td>
</tr>
<tr>
<td>DS&lt;sup&gt;E&lt;/sup&gt;</td>
<td>C 0.06 Mn 0.50 P 0.020 S 0.025 to 0.10, Cr 0.25 Ni 0.20 Cr 0.15 Mo 0.06 V 0.008 Nb 0.008 Ti 0.025 B ...</td>
</tr>
<tr>
<td>HTS&lt;sup&gt;C&lt;/sup&gt;</td>
<td>C 0.02 to 0.15 Mn 0.60 P 0.040, S 0.035 to 0.10, Al ... Cu 0.25 Ni 0.20 Cr 0.15 Mo 0.06 V 0.008 Nb 0.008 Ti 0.025 B ...</td>
</tr>
</tbody>
</table>
**Composition, % Heat Analysis Element, maximum, Unless Otherwise Shown**

<table>
<thead>
<tr>
<th>Designation</th>
<th>C</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cu</th>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>V</th>
<th>Cb</th>
<th>Ti</th>
<th>Nb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 33 [230]</td>
<td>0.20</td>
<td>1.35</td>
<td>0.04</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 37 [255]</td>
<td>0.20</td>
<td>1.35</td>
<td>0.10</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 40 [275]</td>
<td>0.25</td>
<td>1.35</td>
<td>0.10</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 50 Class 1, Class 2, and Class 4 [340 Class 1, Class 2, and Class 4]</td>
<td>0.25</td>
<td>1.35</td>
<td>0.20</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 60 [410]</td>
<td>0.25</td>
<td>1.35</td>
<td>0.20</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
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</tr>
<tr>
<td>Grade 70 [480]</td>
<td>0.25</td>
<td>1.35</td>
<td>0.20</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.008</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 80 [550] Class 1</td>
<td>0.20</td>
<td>1.35</td>
<td>0.04</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.015</td>
<td>0.025</td>
<td>...</td>
</tr>
<tr>
<td>Grade 80 [550] Class 2</td>
<td>0.02</td>
<td>1.35</td>
<td>0.05</td>
<td>0.020</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.10</td>
<td>0.10</td>
<td>0.15</td>
<td>...</td>
</tr>
<tr>
<td>Grade 80 [550] Class 3</td>
<td>0.20</td>
<td>1.35</td>
<td>0.04</td>
<td>0.040</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td>0.06</td>
<td>0.008</td>
<td>0.015</td>
<td>0.025</td>
<td>...</td>
</tr>
</tbody>
</table>

C. **COATING COMPOSITION:**

The 55% aluminum zinc alloy coating composition, by weight, is normally 55% aluminum, 1.6% silicon and the balance zinc.

D. **MECHANICAL PROPERTIES:**

The structural steel sheet shall confirm to the mechanical property requirements as given below for different grades.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Yield Strength, min, MPa</th>
<th>Tensile Strength, min, MPa</th>
<th>Elongation in 50mm, min, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>230</td>
<td>230</td>
<td>310</td>
<td>20</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>360</td>
<td>18</td>
</tr>
<tr>
<td>275</td>
<td>275</td>
<td>380</td>
<td>16</td>
</tr>
<tr>
<td>340 Class 1</td>
<td>340</td>
<td>450</td>
<td>12</td>
</tr>
<tr>
<td>340 Class 2</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>340 Class 4</td>
<td>340</td>
<td>410</td>
<td>12</td>
</tr>
<tr>
<td>410</td>
<td>410</td>
<td>480</td>
<td>10³</td>
</tr>
<tr>
<td>480</td>
<td>480</td>
<td>550</td>
<td>9³</td>
</tr>
<tr>
<td>550 Class 1</td>
<td>550⁰</td>
<td>570</td>
<td>...</td>
</tr>
<tr>
<td>550 Class 2⁰³</td>
<td>550⁰</td>
<td>570</td>
<td>...</td>
</tr>
<tr>
<td>550 Class 3</td>
<td>550⁰</td>
<td>570⁰</td>
<td>3</td>
</tr>
</tbody>
</table>
All tests for mechanical properties shall be conducted in accordance with ASTM standard A924/A924M.

E. BENDING PROPERTIES: Structural sheets are commonly bent by cold bending.

F. DIMENSIONS & PERMISSIBLE VARIATIONS: All the dimensions and permissible variations shall comply with the requirements of specification ASTM A924/A924M.

G. ORGANIC PAINT COATING SYSTEM:

| Regular modified polyester with internal lubricant, suitable for roll forming. | 20 micron of top coat over 5 micron of primer. | 7 micron of back coat over 5 micron primer |

H. THICKNESS:
  i) Basic material the thickness (BMT) = 1.00 MM
  ii) Total Coated thickness (TCT) = 1.09 MM with a tolerance of -0/0.02 mm.

I. TESTING OF MATERIAL: The sheets shall be tested before use to check the following:
  i) Thickness
  ii) Tensile Strength
  iii) Contents of Aluminium, Zinc and Silicon.
  iv) Water tightness

The entire tests mentioned in ASTM codes like the tests given below should be done prior to the installation of the roofing system.

<table>
<thead>
<tr>
<th>SN</th>
<th>PROPERTY</th>
<th>METHOD TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TOP COAT THICKNESS (MICRONS)</td>
<td>ECCA T1-1995</td>
</tr>
<tr>
<td>2</td>
<td>GLOSS AT 60 DEGREE</td>
<td>ECCA T2-1995</td>
</tr>
<tr>
<td>3</td>
<td>PENCIL HARDNESS TEST</td>
<td>ECCA T4-1995</td>
</tr>
<tr>
<td>4</td>
<td>IMPACT TEST (IN JOULES)</td>
<td>ECCA T5-1995</td>
</tr>
<tr>
<td>5</td>
<td>SALT SPRAY TEST</td>
<td>ECCA T8-1996</td>
</tr>
<tr>
<td>6</td>
<td>ADHESION TEST (CROSS - HATCH)</td>
<td>NCCA II - 5</td>
</tr>
<tr>
<td>7</td>
<td>ERICHSEN CUPPING TEST</td>
<td>ECCA T6</td>
</tr>
<tr>
<td>8</td>
<td>HUMIDITY TEST</td>
<td>NCCA III - 6</td>
</tr>
<tr>
<td>9</td>
<td>T-BEND TEST (T=SUBSTRATE THICKNESS)</td>
<td>ECCA T-7</td>
</tr>
<tr>
<td>10</td>
<td>SOLVENT RUB TEST (methyl ethyl ketone - DOUBLE RUB)</td>
<td>ECCA T-11</td>
</tr>
<tr>
<td>11</td>
<td>CHEMICAL RESI. (5% NAOH, 5% H₂SO₄)</td>
<td>ECCA T18-1995</td>
</tr>
<tr>
<td>12</td>
<td>MAX OPERATING TEMPERATURE</td>
<td>ECCA T-12</td>
</tr>
</tbody>
</table>
Annexure – B

i) Layout of RCC Support Arrangement:-

![Image of RCC Support Arrangement]

ii) Layout of Steel Support Arrangement:-

![Image of Steel Support Arrangement]