

## 7. TECHNICAL CONSIDERATIONS

### 7.1 Influence of the design concept

With the emphasis of the design focussed on the (re-)creation of the spatial experience and sensation of the vast and uninterrupted spaces of the station supershed and concourse, enhanced by natural light lighting them up, the desired spatial quality of the enclosures and its minimal visual impairment entailed that in certain structural aspects conceptual considerations took precedence over purely functional or economical solutions.



Fig. 7.1 Rails placed directly on to compacted soil. Capital Park, Pretoria



Fig. 7.2 A thin gravel bed suffices where low train speeds are maintained

The complex consists of five separate structures (the exhibition hall, concourse building, round-house, luxury train passenger departure lounge and company offices, and the rolling stock restoration and repair workshop). These are connected by enclosed lobbies, internal courtyards, or placed separately. Each component has its own structural system, but in essence they all employ a system of steel columns and beams which carry the roof structure. An exception is formed by the reinforced concrete columns carrying inclined steel columns, which, in turn, support the outer edge of the roof on the exhibition hall's long façades, and, also on these, a row of reinforced concrete columns support the hall's walls and mezzanine level floor slab. This latter system was also applied to the concourse building's long façades.

### 7.2 Sub- and superstructure

Sufficient land being available to provide for parking, no basement was necessary. Due to the heavy mass of some of the exhibits, such as track tamping machinery and old railway busses, floor slabs are generally of 340 mm depth on the ground level exhibition areas. Slabs underlying rail track in the exhibition hall, concourse and round-house are of the same thickness, being supported by well-compressed soil. This approach is vindicated by its application at the presently used Friends of the Rail site in Capital Park, Pretoria, where the shunting yard track sleepers are placed on the soil, without even the support of a gravel embankment. It does however preclude the running of locomotives and other rolling stock at any but very low speed, which prevents the vibration and shuddering and consequent sub-base and track damage arising from higher speeds. Tracks for slightly higher speeds can be placed on a thin gravel bed, still sufficient to cope with the effects of this speed. – Column foundations pads are cast to engineer's specifications.

The superstructure of the exhibition hall consists of a steel portal frame spanning 30 m over the four parallel rail tracks displaying the train consists. It is flanked on either side by a 10 m wide bay containing a mezzanine level. The roof stretches for a further 5 m outwards. The complete roof structure forms a double-butterfly roof, with two box gutters. The desire to minimize visual interruption of this space resulted in the individual frames being spaced 11,500 mm apart, half the average carriage length of 23 m, as per '6.7 Design approach'. This directly affected the support of the mezzanine level floor slab. Initially a pre-cast and pre-stressed double-T beam structure was decided upon, which, based on the maximum depth-to-length ratio of 30, provided in *The way we build now: form, scale and technique* (Orton, 1988:36), gives a depth of 383 mm for a the longer span of 11,500 mm, the shorter span of 10 m between the central supporting columns and the wall being made equal to these. On discussing this with engineer Karl von Geyso, he expressed concerns that the ratios provided by Orton are not conservative enough, and that a much greater depth should be used. As this would have impaired the visual impact of the space below the mezzanine level, this proposal was rejected, and a steel beam grid support structure decided upon. With Orton's maximum ratio for rolled steel universal beams of 25 (Orton, 1988:41), with which the engineer felt more comfortable, the universal beam depth was determined as 475 mm for the span of 11,500 mm. This dimension was once again used in both dimensions. The actual floor slab being recessed from the line of the central columns, intermediate support for the permanent shuttering (QC Flooring Standard permanent shuttering by HH Robertson) was provided over 6,232 mm by rolled steel universal beams of 375 mm depth at centre-to-centre intervals of 3,833 mm. Only 250 mm depth would be required, but the greater depth was used for visual considerations, accentuating the structure.

The roof structure of the round-house was initially supported by steel universal beams, but a span of 18 m would have necessitated a visually very heavy beam depth. The problem was exacerbated by the need to support the suspended glass curtain wall from the cantilevered ends of these beams, which would further have increased the depth of the beams and their supporting columns. The beams were thus substituted by trusses.

The concourse's roof is supported by steel trusses on steel universal columns, that of the luxury train passenger departure lounge building by steel universal beams on steel universal columns, and the workshop's structure is made up of steel portal frames, the vertical portion being clad in concrete. Column and beam dimensions have been computed by the application of the material's length/depth ratios as set out in the tables in Orton (1988:30-52), but are subject to engineer's calculations. The same applies to the depth of concrete roof slabs.

### 7.3 Choice of materials

The choice of materials was influenced by historic precedent. The now demolished workshops and the still existing steam hammer shed on the site were in the main constructed of steel frames, clad with corrugated iron, and glass for windows and skylights. The floor slabs were of concrete. The existing Chief Engineer's Office building is a brick structure. These materials, steel, corrugated iron (or its modern derivative, IBR boards), brick and glass, were used in the museum design, plus sandstone for occasional exterior cladding and anodized aluminium louvres to assist with controlling the in-fall of the sun's radiation.

A large portion of the exterior surrounding area (terraces and the approach to museum complex) is paved with clay pavers. Concrete grass blocks are used for the parking bays, whereas the area used by moving traffic is tarred. Within the exhibition hall, concourse, round-house and workshop structures, the concrete slabs are floated and left with their natural finish. This will reduce the damage resulting from the movement and display of heavy items. Hard-wearing carpet tiles are used on the exhibition hall's mezzanine level floor, as only lighter exhibits are displayed here. The departure lounge building reception area, offices and traffic areas of the lounge have a wood laminate floor covering, the other part of the lounge carpets. The floor covering of all bathrooms and kitchens consists of terracotta tiles.

Interior walls are in the main plastered and painted, unless raw face brick surfaces are shown. Steel structural elements are coated with an intumescent paint. Kitchen and cloakroom walls are clad with ceramic tiles to ceiling height, facilitating cleaning. Ceilings, either consisting of permanent shuttering, concrete, insulation board or IBR-sheeting, are generally finished in light colours, increasing their reflectivity of light, to enhance the desired ambience and reduce the need for artificial lighting.

Glass is either clear or tinted, depending on the degree of exposure to the sun's radiation or the shading obtained by the installation of louvres.

Roofing material is either concrete, for slabs, or IBR-sheeting. Concrete slabs are protected by torched-on membranes for waterproofing, coated with reflective paint. The IBR-sheeting is made of Zincolume steel, the manufacturer BHP's brochure showing that in the weathered state it radiates only about a third of the heat, measured in  $W/m^2$ , that standard galvanised steel does. (When new, it radiates more, but the long-term benefit outweighs the initial shortcoming.) (BHP, 2007:1). The recommended Safintra Saflok 700 profile is available in this material, and laying this with the minimum  $2^\circ$  slope, as recommended in the manufacturer's brochure (Safintra, 2007:10), becomes aesthetically satisfactory in the proposed design, in that it appears to be (almost) flat, when viewed from below and even from a fair distance.

#### **7.4 Suspended glass wall**

The design of the round-house's exterior wall is a curved row of columns steadily increasing in height to 6,545 mm, with the space over and between them filled with a suspended toughened glass wall to roof height of 7,000 mm. Per the information leaflet supplied by PFG, the maximum height for this application, using their 12 mm Armourplate glass, is 23 m. As the opening to be closed is a lesser 7,000 mm, the 10 mm glass will be used. The glass panels making up this curtain 'are fixed to the top rail [attached to the roof or a wall] by metal hangers bolted to the top edge and subsequent rows of panels then assembled downwards. The panels are bolted together at their corners by small metal fittings and the joints filled with a flexible silicone seal. In suspension, the edge and bottom panels are free to move in metal channels, allowing the whole assembly to float with the building structure. Lateral stability is given by toughened glass stabilising fins at each vertical joint. These fins can be continuous from top to floor, or cantilevered, rooting at the ceiling or floor.' (PFG, 2007:4) With the columns rising from the south-west to the north-east, and the prior being shaded by the concourse building and the taller columns shading the north-east facing glass panels for the greater part of the day, it was decided to use clear glass, making the displayed locomotives visible. – The same approach is applied to the glass curtain walls of the concourse building.

#### **7.5 Thermal control**

The design attempts to reduce operating costs and address sustainability issues, further addressed '7.5 Sustainability issues' below, by looking at means obviating the need for air-conditioning. A precedent is set for this by the James Hall Transport Museum in Johannesburg, discussed under 5.5. This entailed the encouraging of natural ventilation and the reduction of the amount of direct sun radiation into the structures, whilst not obstructing the illumination that can be obtained by the infall of indirect sun light.

Natural ventilation makes use of the principle that warm air rises, and accordingly ventilation louvre panels were provided below the roof of the concourse and the outer bays of the exhibition hall. Ventilation louvres were also placed in 'boxes' atop the exhibition hall's central bay and the workshop. To increase the draft of the ventilation, the heat build-up in the proximity of these high-placed louvres seeking escape through them could be increased by painting the roof-surface black. The accelerated air flow will draw more air into the structure. Furthermore, using the Zinalume-steel roof sheeting, as set out under 7.3 above, should substantially reduce the heat build-up in the volumes so covered. In addition, insulation boards placed under the roofing sheets of the exhibition hall will reduce heat building up. The high volumes in themselves will assist in keeping temperatures at the lower levels cooler. – The round-house is open to the turntable

side. The departure lounge building has opening windows; should these prove to be insufficient, air-conditioning units may be inserted below the individual window frames. Once again, the high volume of the lounge itself, and opening French doors and windows, will assist it remaining cooler. It is considered that these measures will make providing a centrally controlled air-conditioning system superfluous, and accordingly none has been included in the design.

Sun radiation ingress is limited by the placing of louvres, either horizontal or vertical, and where this was not considered feasible, by tinted glass. The use of the latter was limited as much as possible, due to its heightened mirror-like reflective appearance from the outside. Ample use was made of glass facing the south-east: in the mornings, the brief infall of sun would reduce the night chill in the ambient temperature, but the sun would then move on and by mid-morning have passed the (too) direct infall azimuths. Sliding doors in the concourse area will allow for a compensating movement of air. As explained under The openness of the

The kitchens and sanitary facilities are provided with extractors to the outside or to shafts, as is appropriate to their placement.

## **7.6 Sustainability aspects**

The sustainability-related aspects with regard to thermal control and ventilation have been set out above.

A further sustainability-related features incorporated in the design is the inclusion of four large water tanks, in total of about 82,000 litres volume, in the internal courtyard, acting as recipients of the round-house's and concourse building's roof run-off, and providing irrigation water for the complex's garden. If so desired and depending on requirements, similar tanks may in the future be installed for the exhibition hall's roof run-off, in the area of the repair yard or its proximity.

The parking bays are surfaced with concrete grass block pavers, permitting the percolation of rain into the soil.

The roofs provide opportunity to install photovoltaic cell sun-panels, but have been omitted from the initial design due to their high initial capital cost off-setting energy consumption savings for a lengthy period. They may be installed later at the discretion of the museum's trustees. Furthermore, recently, critique has come forward as to their sustainability, as their production is said to require more energy than they will eventually save.