Composite floor at Luxembourg Chamber of Commerce

The new headquarters of the Chamber of Commerce of the Grand Duchy of Luxemburg was completed in 2004. It is located on the Kirchberg plateau of Luxembourg and comprises a fully renovated existing building of 5,000 m^2 and new buildings providing an additional 20,000 m^2 of office space. The new buildings form a succession of four distinct wings linked together by glass footbridges. They have a steel primary frame with glass and steel façades, and the floors are designed as composite slabs using stainless steel panels profiled in a sinusoidal shape. Within the composite floor slab, water-carrying plastic pipes are placed to provide heating and cooling through the exposed stainless steel ceilings, leading to significant energy savings.

Figure 1: Profiled stainless steel decking

Material Selection

In the design of the exposed floor soffit, the architect was looking for a reflective appearance that blended in with the surroundings. Stainless steel decking was selected for the floor because of the wide range of surface finishes possible, its strength, formability and long-term durability. The austenitic stainless steel grade 1.4301 (S30400) was chosen, with a specified minimum 0.2% proof strength of 230 N/mm^2 and ductility of 45%, more than twice the ductility of carbon steel. This grade of stainless steel is suitable for internal applications and external rural, urban or light industrial environments and has the required formability for roll forming into the sinusoidal profile.

The specified finish applied to the material was the basic 2B mill finish in accordance with EN 10088-2 [1]. To achieve this finish, the strip is cold rolled, heat treated, pickled and skin passed. The material has a smooth, pearly semi-lustrous appearance and is the most common finish applied to stainless steel.

Figure 2: General view

Design

The four and five storey structures have steel frames constructed from hot rolled sections and composite floors. Slim floor construction was adopted for the composite floor: the main beams are HEM260 steel profiles (H sections, 290 mm deep and 268 mm wide). A 350 mm wide x 20 mm thick plate welded to the bottom flange, supporting a 380 mm deep composite slab section. The 12.5 m long beams are under-tied by tubular sections to increase their spanning capabilities by up to 30%. The ties are exposed below the floor yet still visually unobtrusive. Services pass below the beams and above the ties to minimise the floor depth.

The slab comprises a 180 mm deep stainless steel sinusoidal profile decking and in-situ concrete. The decking spans between the main beams which are at 3.75 m centres. Both the beam and the decking were designed to act compositely with the in-situ concrete. The diaphragm action of the floor slabs also helps provide the horizontal stability of the building.

The design imposed load was 4.5 kN/m^2 and the self weight of the construction was 4.6 kN/m^2. A fire engineering analysis was carried out to demonstrate that 60 minutes fire resistance could be achieved by the steel beams and exposed floor without applying any fire protection. The slim floor beams are partially protected by the concrete slab and support the reduced design load in fire situations despite the loss of the exposed ties. Temperatures in the design fire scenarios were around 600°C, at which point the stainless steel retains at least 50% of its room temperature strength. The deformation in fire was estimated as less than 100 mm.

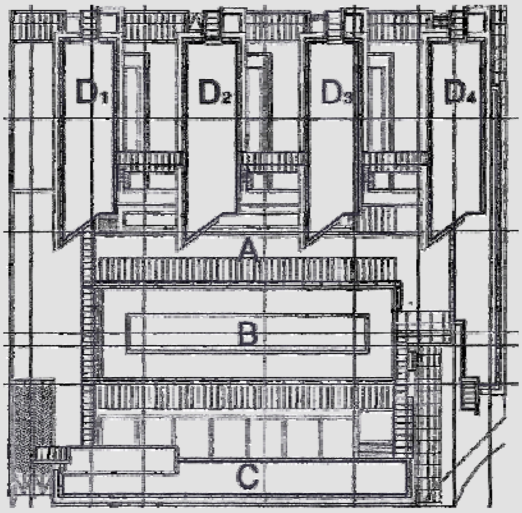

Figure 3: Plan view of the buildings (B is the existing building, C and D_n are the new buildings)

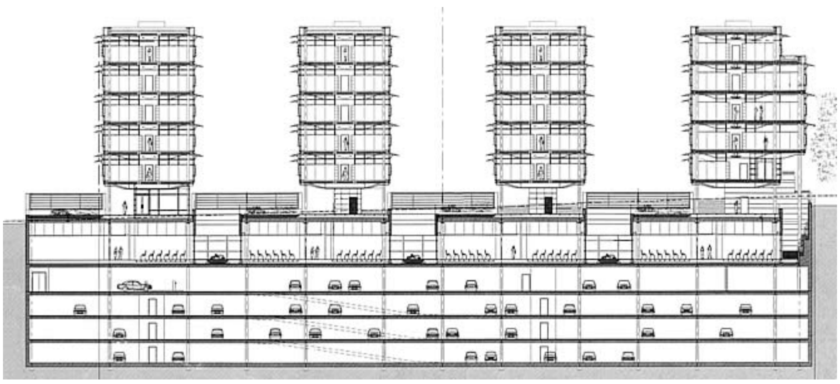

Figure 4: Elevation view of the new buildings

Figure 5: Architectural rendering

Water cooled floor slab: Heating and cooling arrangement

For the energy efficiency strategy, the operating conditions of the water-cooled slab are in 3 cycles, as follows:

Summer – night time: Cool water runs through the embedded plastic pipes in the slab to remove the heat built up in the slab during the day.

Summer – day time: If the night-time cooling of the floor slab does not reach the required temperature, the cooling circuit keeps functioning and is assisted by absorption chillers (which use a heat source to drive the cooling process). Once cooled sufficiently, the water circuit is reversed and passes the cold water through heat exchangers, which are partially powered by solar collectors on the roof. Pre-treated air is also then blown through the exchangers to be cooled and is mixed with the existing air in a "venturi" effect. This cold mixed air is distributed throughout the building to provide cooling during the day time.

Winter: The floor slab is heated in the winter months by passing hot water through the pipes in the floor slab. The supply water is heated centrally, supplemented by heat generated by the solar collectors.

Figure 6: Lighting and air distribution units suspended from the profiled decking

Figure 7: Corner detail of profiled decking

Figure 8: Water heating/cooling pipework placed within the floor slab

Fabrication and Erection

The stainless steel decking was manufactured from approximately 1.0 mm thick steel sheet. Each sheet has three sinusoidal ribs of 312 mm pitch making the sheet width 936 mm. The decking was designed to support the weight of wet concrete and other construction loads without propping over its 3.4 m clear span (3.75 m less 0.35 m plate width). The decking provided sufficient shear bond with the concrete so that, when the concrete gains strength, the two materials act together compositely. Composite action between the beams and the slab is achieved by welded shear connectors on the beams.

The decking was lifted in bundles and each piece was man-handled into position. The weight of a single sheet was less than 50 kg, making it easy for two men to lift. Each piece was then placed on the extended flange of the integrated beams. The ends of the decking were closed to prevent loss of concrete. The joint between adjacent sheets was at the top of every third rib, to allow it to be fixed easily. Decking was fitted at a rate of 300 m^2 per day and was cleaned manually as the construction proceeded.

Figure 9: Erection of the structural steel framework

References and Bibliography

[1] EN 10088-2:2005 Stainless steels. Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes.

[2] Commercial Buildings: Guidance for architects, designers and constructors, SCI, 2008

Photos and drawings were provided by ArcelorMittal.

Online Information Centre for Stainless Steel in Construction:
www.stainlessconstruction.com

Procurement Details

Client:	Luxembourg Council
Architect:	Vasconi Architects
Structural Engineer:	Schroeder N Green and A Hunt
Services Engineer:	RMC Consulting
Contractor:	Hochtief
Deck profiling:	PMA, Cérons, France

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