State Street Bank, Luxembourg

M. Haller
ARCELOR Long Carbon Steel, Research Department

1 GENERAL INFORMATION

Client:
State Street Building Kirchberg S.A.

Architect:
Atelier a+u

Planning of structural framework:
Schroeder & Associés S.A.
TR-Engineering

Executive company:
HOCHTIEF Luxemburg S.A.

Fire protection expertise:
PROFILARBED-Research

Processing time:
2000 – 2001

Kind of building:
Office building with 4 floors (+ 3 floor underground car park)

Total height:
21.6 m

Ground-plan:
63 × 38.8 m

Figure 1. Main façade of the building

2 INTRODUCTION

The first phase of the office building, which contains the "State Street Bank" is built on the "Kirchberg" in Luxembourg city. This area is close to the city centre and represents the new business area of Luxembourg.

3 STRUCTURE

The upper floors, used for offices are made of long span composite beams and partially encased columns. In the underground floors, dedicated to parking, the structure is identical except that the beams are also partially encased.
The frame is constituted of 4 levels of 3 bays (15,15 m, 8,5 m and 15,15 m). The ground level is at 0 m, first floor is 4,5 m, second, third and roof are respectively 8,7 m, 12,9 m and 17,1 m (4,2 m per storey).
The distance between adjacent main frames is 4,5 m. Decks are 36 cm thick and are made of a 16 cm C30/37 concrete floor (including a pre-cast slab of 5 cm) and a 20 cm floor finishing.
The beams are composite beams made with steel of grade S355 (Span of 8.5 m) and S460 (Span of 15.15m). The steel beams are connected to concrete floors with studs ϕ22x125 mm.

The composite columns are made of steel profiles in grade S355 filled with concrete of class C30/37, which are always continuous on 2 storeys. Although the connection between the columns is made of 4 bolds flush end plate at level 12,9 m, the connection is considered as rigid due to its high axial load.

Figure 2. Side view of the building during construction

The columns are considered as pinned at ground level. Concrete cores required by stairs and elevators provide horizontal stability.

Before the fire resistance study, internal columns were only submitted to axial load as the connected beams were simply supported. External columns are submitted to lower axial load (comprising the weight of the facades) but also to bending as they transmit the wind forces to the floors. The bending moments due to wind are very low by comparison to axial load and do not present any influence on the design of the columns. External columns on corners are submitted to the minimum axial load (comprising the weight of the facades) but also to bending in both directions due to wind. The bending moments due to wind are still low by comparison to axial load and do not present any influence on the design of the columns.

4 FIRE SAFETY CONCEPT

PROFILARBED-Research department has been asked to perform the fire engineering of the upper parts of the structure.

The authorities accepted to apply the Natural Fire Safety Concept [1, 2, 3]. The fire design was based on the prescriptions of EN 1991-1-2 [1] (Characteristic fire load for office building: 511MJ/m^2) and by taking into account the active fire fighting measures (Automatic alarm & transmission to the fire brigade, smoke exhaust systems…). No sprinkler were foreseen.

The gas temperature has been calculated using the 2 zone software OZone [1, 2]. A set of simulations has been made, by analysing different compartments and by using several glass breaking scenarios. As the maximum resulting steel temperatures in the IPE 600 sections reached up to 850 °C, a 2-D finite element analysis had to be performed taking into account the whole structure of the building. The most loaded frame was simulated with the FE software Ceficoss [5]. The static loads under fire conditions according to prEN1990 [6] were applied.

Figure 3. Detail of the connection

The beams have been initially designed as simply supported, but due to recommendations from PROFILARBED-Research in a former project, an extended endplate has been used with one row of bolds situated in the concrete layer. This ensures that in case of a fire, at least one row of bolds remains cold and is able to transmit the "reduced" shear forces. This positive effect has been taken into account in the FE analysis and by adding some additional rebars on middle support, a negative bending moment could be activated. By this it was proved that the structure would survive a natural fire.

The result of this fire engineering approach was that the whole steel beams could remain without any passive fire protection.

For the underground levels the authorities asked a fire resistance of R90. This was achieved by using partially encased columns and beams with the needed reinforcement.

REFERENCE

[1] EN 1991-1-2, Eurocode 1- Actions on structures, Part 1.2-Actions on structures exposed to fire. CEN Central Secretariat, Brussels, November 2002

[2] Competitive steel buildings through natural fire safety concept. ECSC Research 7210-SA/125; 1994-98

[3] Natural fire safety concept –Full scale tests, implementation in the Eurocodes and development of a user-friendly design tool." ECSC Research 7210-060, 1997-2000;

[4] Valorisation project - Natural Fire Safety Concept." ECSC Research 7215-PA/PB/PC –042-057, D-E-F-I-NL-UK & ECCS, 1999-2001.

[5] CEFICOSS , A Computer Program for Analysis of Structures Submitted to the Fire, University of Liège, Department Structures du génie Civil, Service Ponts et Charpentes

[6] CEN; prEN1990, Eurocode – Basis of structural design, 2001.