Shopping centre Cactus, Esch/Alzette (Luxembourg)

O. Vassart
ARCELOR Long Carbon Steel Research Centre

1 GENERAL INFORMATION

Client:
Cactus S.A.

Architect:
Paczowski Fritsch Associés

Planning of structural framework:
Schroeder & Associés S.A.

Executive company:
MABILUX S.A.

Fire protection expertise:
PROFILARBED-Research

Processing time:
2003

Kind of building:
Shopping Centre (Single storey building)

Total height:
9.13 m

Ground-plan:
28.51 × 48.16 m

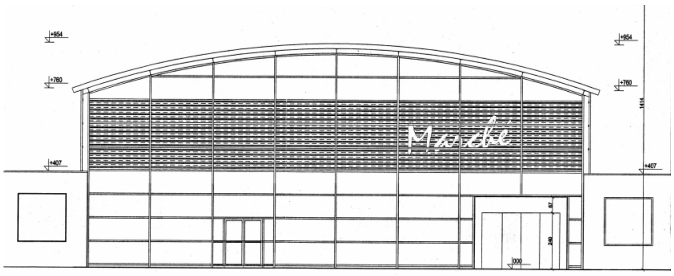

Figure 1. Main façade of the building

2 INTRODUCTION

This medium size supermarket is situated in the city centre, of Esch/Alzette and it will replace an older structure, which is situated in the proximate neighbourhood. The owner wanted to have a non-typical hall and opted for an open space with huge glassing surface in two of the facades. The steel structure, with long span curved cellular beams should maintain visible.

3 STRUCTURE

The structure is a hall made up with portal frames comprising steel columns and cambered cellular beams. The frames are interconnected by means of steel roof purlins and bracing system.
The frame is constituted one bay of 20 m span. The ground level is at 0 m, the top of the column at 7.55m and the top height in middle of the cambered beam is 9.13 m.
The distance between adjacent main frames is 7,5 m. Frames are connected by continuous purlins (IPE200). The roofing is made with a steel sheet (HOESH TR44A), insulation and waterproofing.
The beams are Arcelor Cellular Beams © build from an HEB 450 in S235. The height of the final beam is 590 mm, the openings diameter is 400 mm and the distance between the openings axes is 600 mm. The distance between the edges of two consecutive openings is thus 200 mm.

The columns are made of steel profile (HEB 500) in grade S235. Although the connection between the columns and the beams is made of 10 bolds flush end plate at level 7.55 m, the connection is considered as rigid to assume the portal frame effect

Figure 2. View of the building during construction

The columns are considered as pinned at ground level. The horizontal stability is ensures in one direction by the portal frame affect and by a bracing system (on each side of the building) in the other direction.
External columns are submitted to lower axial load (comprising the weight of the facades. External columns on corners are submitted to the minimum axial load (comprising the weight of the facades) but the sections of theses columns are similar to the other.

4 FIRE SAFETY CONCEPT

For such structures, with steel structures supporting the roof, a fire resistance of 90 minutes is required.
PROFILARBED-Research 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 [2, 3, 4]. The fire design was based on the prescriptions of EN 1991-1-2 (Characteristic fire load for office building: 730MJ/m^2) [1] and by taking into account the active fire fighting measures (Automatic alarm & transmission to the fire brigade, smoke exhaust systems…). No sprinklers were foreseen due to the small size of the building.

The gas temperature has been calculated using the 2 zone software Ozone [2, 3] and localised temperature were calculated using Hasemi methodology [1]. A set of simulations has been made to analyse the breaking of the glazed surfaces (front and back façades are completely glazed. As the maximum resulting steel temperatures in the columns reached up to 880 °C, a 3-D finite element analysis was performed, taking into account the whole structure of the building. One complete model of the building in 3 dimensions was analysed. But some characteristic aspects of the Arcelor Cellular Beams © behaviour were not considered in this model, such as Vierendeel mechanism and web post buckling. A sophisticated shell finite elements model was then developed in order to take these phenomena into account.

All the simulations were made using the FE software SAFIR [4]. The static loads under fire conditions according to prEN1990 [5] were applied.

Figure 3. Detail of the connection

A concrete beam supporting the roof of the two lateral annexes and supported by the steel columns was initially designed as simply supported (from one column to another), but due to recommendations from PROFILARBED-Research it became continuous on the length of the building.
Concerning the profiles, they were sufficient to resist to the defined scenarios. But concerning the welding of the Arcelor Cellular Beams ©, the cold design resulted in 3 mm fillet weld each side of the web and we imposed 5 mm. By doing so the structure was shown to survive a natural fire.

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

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
[3] Natural fire safety concept –Full scale tests, implementation in the Eurocodes and development of a user-friendly design tool." ECSC Research 7210-060
[4] SAFIR , A Computer Program for Analysis of Structures Submitted to the Fire, University of Liège, Department Structures du génie Civil, Service Ponts et Charpentes (2000)
[5] CEN; prEN1990, Eurocode – Basis of structural design, 2001.