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BED JOINT REINFORCED MASONRY UNDER LATERAL LOADING

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Abstract

The paper deals with the application of bed joint reinforced masonry in lateral loaded masonry panels.
This application was realised during the construction of the ARENA sport complex in Budapest where the inner walls were relatively high (4 to 8 m) and submitted to lateral loading (wind pressure).
The initial solution consisted in the construction of concrete block masonry walls with at each side 5,40 m high columns and tied together with 2 ring beams. By using MURFOR bed joint reinforcement, the wall thickness could be reduced and the ring beams could be deleted. This solution provided both a more economical, technical and also a more esthetical construction.

Key Words

Reinforcement - Murfor.

1 Introduction

The walls inside of the sport and recreation complex have different particularities:
- they are relatively high (4 à 8 m)
- they are submitted to wind loads and loadings coming from the presence of the high number of participants.

The traditional solutions for these cases make use of reinforced concrete walls or masonry walls supported by columns and connected with RC beams
These solutions are however:
- not esthetical and
- not economical

Bed joint reinforced masonry is here a valuable alternative.
In this paper the application of bed joint reinforced masonry in the spectacular ARENA, sport complex in Budapest, Hungary will be presented.

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2 Building description

The construction was designed by the architects, Köszti of Budapest, Hungary, Sport-concepts of London UK and built by Bouygues. The construction represented a spectacular "stone" form (fig. 1) of 41.000 m² and a capacity of max 12.500 visitors.
The structure is from R.C. and the roof, supported by a steel frame, was developed in a synthetic material developed in Switzerland.

Fig. 1 Arena Sports Complex Budapest

3 Conception of walls

For esthetical and economic reasons the walls were initially designed in concrete block masonry without rendering. The walls were supported by columns each +/- 5,40 m and tied by 2 ring beams dividing also the wall in 3 independent parts.
The proposal to use a reinforced masonry structure was made January 2002. The R.C.-structure was already present so there was no possibility to change the distance between the columns. The proposal consisted now to avoid the ring beams and use bed joint reinforced masonry (Murfor). As such the wall thickness could be reduced from 30 cm to 20 cm. This solution results in a substantial economic and also nice looking "facing" block masonry aspect.

4 Calculation.

The calculation is made according to the Eurocode 6 Design of Masonry Structures Part 1-1 – prEN 1996-1-1 (the existing edition of begin 2002).

4.1 Input Data

Internal wind load (inside building) : (0,3 + 0,3) x 0,633 = 0,38 kN/m²
Wall supported at 3 sides (1 free side on top).

4.2 Strength of the masonry

Mean compressive strength of the concrete blocks	f_b = 2,5N/mm²
Compressive strength of mortar	f_m = 2,5 N/mm²
Dimensions of the concrete blocks	300 / 200 / 220 mm
Type Concrete blocks:	Masonry category 2b → K = 0,5

Char. Strength of masonry perpendicular to the bed joints

$$f_k = K \cdot f_b^{0,65} \times f_m^{0,25} = 1,25 \text{ N/mm}^2$$

This allows the calculation of the following values :

Char. Strength of masonry parallel to bed joints
$f_{kh} = 0,3\ f_k = 0,37$ N/mm²

Char. Shear strength of masonry
$f_{vk} = 0,2 + 0,00 = 0,20$ N/mm²

Char. Flexural strength of masonry
$F_{xk1} = 0,10$ N/mm²

The following safety factors are taken into account:
- load factor 1,50
- safety factor on masonry 2,20
- safety factor on steel 1,15

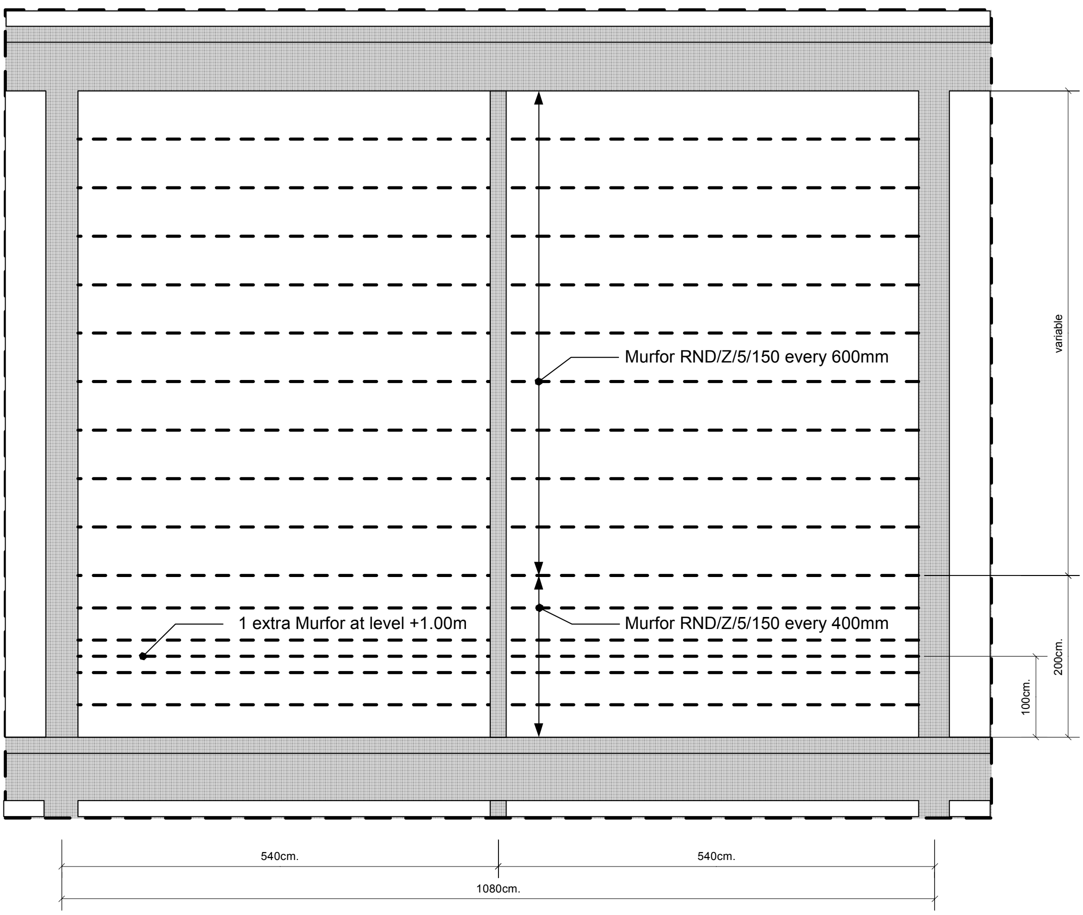

Figure 2. Detail of bed joint reinforcement

4.3 Bending moments

The maximum bending moments are calculated according to prEN-1996-1-1
Every 60 cm a MURFOR reinforcement with longitudinal wire of 5 mm in diameter is put into the bed joints (fig. 2)
The width of the reinforcement is 150 mm.
The effective height is d = 175 mm

The orthogonal ratio μ is equal to μ = 0,16
From the table (Annex E) we find for l/h = 1,25 α = 0,104

Moment in horizontal direction : Msd1 = $\gamma_f \cdot \alpha \cdot p \cdot l^2$ = 1,16 kNm/m
Moment in vertical direction : Msd2 = $\gamma_f \cdot \mu \cdot \alpha \cdot p \cdot l^2$ = 0,18 kNm/m

4.4 Calculation of the reinforcement

$$A\ min = 2\ \frac{\gamma_s \cdot \gamma_f \cdot M_{d1}}{z \cdot f_{yk}} = 65{,}45\ mm^2/m$$

$$\text{With } z = \left(1 - 0{,}50\ \frac{A_s \cdot f_{yk} \cdot \gamma_m}{b \cdot d \cdot f_{kh} \cdot \gamma_s}\right) d = 133{,}2\ mm$$

Verification (prEN1996-1-1 - §8)

A min = 0,030 % of the section = 60 mm²/m

which is smaller than 65,450 mm²/m.

4.5 Stresses

4.5.1. Compressive stresses due to bending parallel to the bed joints

z/d = 0,76 c = 0,36

$$f_{kh} > \frac{\gamma_m\ \gamma_f \cdot M_{sd1}}{c \cdot b \cdot d^2} = 0{,}34\ N/mm^2 < 0{,}37\ N/mm^2$$

4.5.2. Shear Stresses

$$f_{vk} > \frac{\gamma_m \cdot \gamma_f \cdot V_{sd}}{b \cdot d} = 0{,}02\ N/mm^2 < 0{,}20\ N/mm^2$$

4.6 Reinforcement

The wall should be reinforced with bed joint reinforcement having wires of 5 mm in diameter and a width of 150 mm. The vertical spacing was maximum 60 cm (see fig 2). The overall sectional area of one bed joint reinforcement is 39 mm².

On the base level of the panel, the reinforcement will be increased for crack prevention coming from deformation of the slab (see fig 2).

5 Execution

The following photographs (see fig 3, 4 and 5) show the masonry with Murfor reinforcement during the execution.

Figure 3. View on reinforced masonry wall during execution.

Figure 4. Execution of bed joint reinforcement.

6 Conclusion

The building has been used now for about 1 year. The alternative solution with bed joint reinforcement fulfilled different criteria: technically performing, economically beneficial and from an architectural point, a more esthetical outlook.
This example has served as a reference for the construction of other sport centres such as Benfica , Braga, Coimbra in Portugal.