The glazing for the stairs in the refurbished Margherita Theatre in Livorno

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Outline

1_ Introduction
2_ The Architectural issue
3_ Our Technical proposal
4_ Details
5_ Conclusions
Teatro Margherita, Livorno

1913  Opened as a cinema
1990  Abandoned and closed
2015  Refurbishment by a private business

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Teatro Margherita, Livorno

2015
Refurbishment:

- Convert the theatre in a shopping center
- Join the ground floor level to the gallery level
- Preserve the architectural and historical value of the building

“A new **double flight open string steel staircase** completely covered by marble was designed”
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Architectural constraints

ARCHITECT’S REQUESTS
- all the parapets completely transparent
- no steel and aluminum frames

DIMENSIONS AND STAIR
Architectural constraints

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DIMENSIONS AND STAIR
Architectural constraints

- **ARCHITECT’S REQUESTS**
  - all the parapets completely transparent
  - no steel and aluminum frames

- **DIMENSIONS**
  - steel staircase elevation = 4668 mm
  - length of the lower staircases = 5395 mm
  - length of top staircases = 5650 mm
  - gap between ramps = 90 mm

- **THE STAIRS**
  - thin steel structure covered by marble
  - joined by means of steel anchors
  - already installed

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The Refurbishment
Our Technical proposal

The glazing for the stairs in the refurbished Margherita Theatre in Livorno

- **GL1** _Central laminated glazing with horizontal laminated glass fin_
- **GL2** _Lateral laminated glass parapet_
- **GL3** _Secondary laminated glass parapet_
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Static schemes

GL1

Central laminated glazing with horizontal laminated glass fin

GL2

Lateral laminated glass parapet

GL3

Secondary laminated glass parapet

“... a specific static scheme, to be translated in the effective technical detail”
Details

All the panels are linked to the treads of the staircase by means of joints, in order to ensure out-of-plane constraints to the glass elements.
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**GLASS_1**

- **Type A**: 1001 x 2280
- **Type B**: 1001 x 3473
- **Type C**: 1481 x 500

<table>
<thead>
<tr>
<th>Glass panel</th>
<th>Size [mm x mm]</th>
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</thead>
<tbody>
<tr>
<td>Type A</td>
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12+12 thick fully tempered glass (FTG) layers laminated 1.52 mm PVB interlayer
3. Our Technical proposal

GLASS_1

The glazing for the stairs in the refurbished Margherita Theatre in Livorno

All the glass panels are joined together by means of 9 glass-to-glass steel joints

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**GLASS_1**

**BOTTOM EDGES**
continuous horizontal split in the ground floor

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Special steel joints that exert an out of plane restrain for the glass elements and allow the free vertical deflection of the staircase.
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**GLASS_1**

- Type A
- Type B
- Type C

**TOP EDGES**

Horizontal laminated glass fin

Structural steel handrails
GLASS_1

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TOP EDGES
The glazing for the stairs in the refurbished Margherita Theatre in Livorno

GLASS _1

HANDRAILS
Structural function of the handrails:
- distribute the imposed horizontal load (2.0 kN/m)
- reduce the out of plane deflection due to that load
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**GLASS_2**

<table>
<thead>
<tr>
<th>Glass panel</th>
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<tbody>
<tr>
<td>Type D</td>
<td>1481 x 3473</td>
</tr>
<tr>
<td>Type E</td>
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</tr>
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</table>

8+10+8-mm-thick fully tempered glass (FTG) layers laminated 1.52 mm PVB interlayer
All the four laminated glass panels are joined to the first level slab by means of mechanical fixings.

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**GLASS_3**

8+10+8-mm-thick fully tempered glass (FTG) layers laminated 1.52 mm PVB interlayer
The glass panel edges are shaped with eyelets to host the joint; this way there cannot be any vertical sliding of the joint on the glass.
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Modelling

LOADINGS
- According to NTC08 and CNR 210/13
- 2.0 kN/m imposed horizontal load
- Panel break-up situation

MODELLING
- Strand7 FEM software
- Considering handrails and the glass fin
- Modelling steel joints and polyethylene gaskets between steel and glass
Conclusions

- Glass split in two rows of panels, making it a hypostatic structure

- Restraint = joining the wall to the steel staircase + horizontal glass stiffening fixed to the wall extremities

- Design process considering minimum assembly tolerance, design tailor-made joints and possible panel brake-up

- Approach based on parametric CAD design to define the exact positions
Thanks for your attention

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