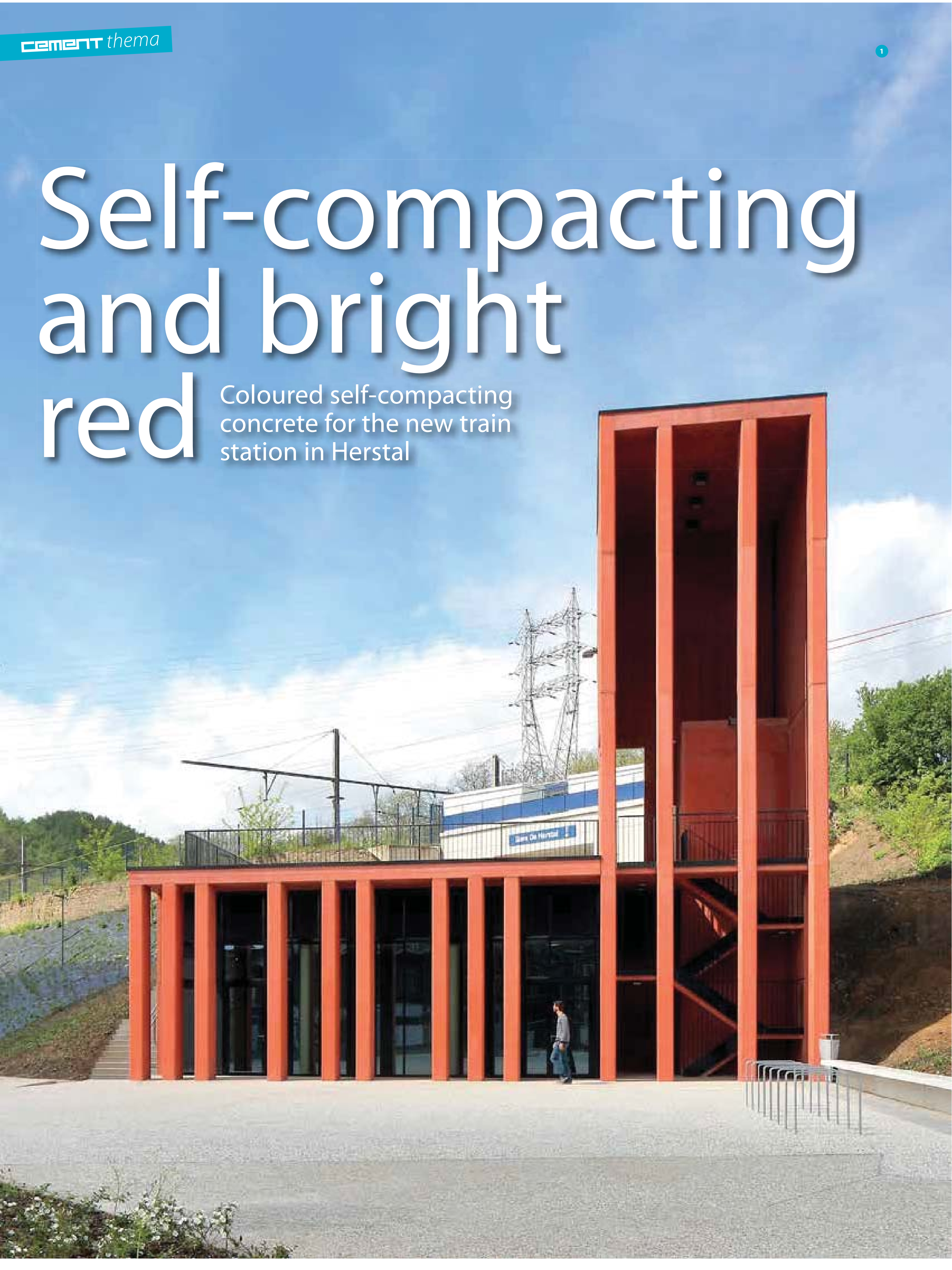
Self-compacting and bright red

Coloured self-compacting concrete for the new train station in Herstal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The new train station in Herstal, Belgium, stands as the new landmark of the city. Now connecting city parts previously disconnected, the high tower of the station ensures visibility and is becoming the symbol of the town. Beyond the strength of the architectural shape itself, the concrete building has a solid, red colour.

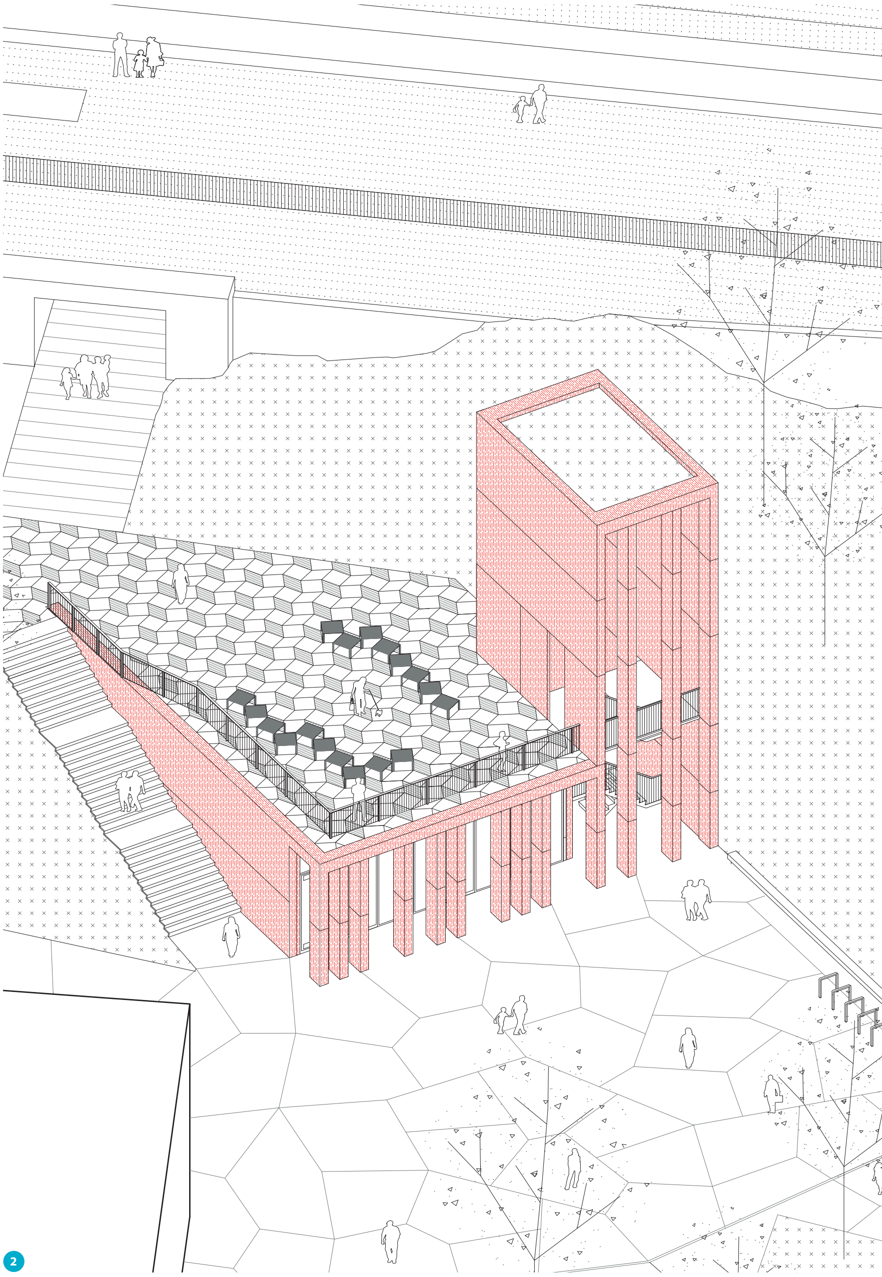
For its flexibility and in order to fulfil the structural and aesthetics requirements of the tower of the new train station in Herstal, ready-mix concrete has been chosen. In addition, the self-compacting property of the concrete facilitated meeting the aesthetic requirements for the concrete surface.
This paper redraws the main steps in the development, the production and the pouring of a self-compacting red concrete used for the construction of the building.

Architecture and landscape

The 'Pôle Marexhe', or the site of the urban renewal project, was a dense and decrepit city block, lacking public space, and hiding the green and hilly landscape in the background. This old city block was demolished and is replaced by a set of city spaces such as a new train station, four collective housing buildings including shopping facilities located around a new public square (fig. 2 and 4).

The new train station has been considered as the opportunity to create a link between two different levels of the city: the lower level valley (consisting of the square and the dense urban/industrial fabrics) and the upper, green landscape level (consisting of the hillsides and the park).
The concept of the building-square integrates two main stakes:
- generating an intermediate level, a belvedere;
- connecting the different levels of the public space.

Choosing the proper material was a key element of the project. The station is built in red self-compacting concrete (photo 1). The lateral sides of the building have a raw texture imprinted by the timber formwork (photo 3 and 5). This sober and raw expression character of the building is the inherent identity of the project. The front facade is smooth and is facing to the users of the public space.



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First phase: study on the construction method

The tower of the station connects visually all the different levels of the project. It acts as a landmark for the city, allowing the train travellers to directly find their bearings. The tower contains the - direct - vertical circulations such as the elevator and stairs.
The height of the tower (16 m) is defined by the height of the surrounding landscape. Tower is peculiar because it does not have floors on its upper part (last 9 m out of the 16 m), making it more difficult to attain a satisfying structural rigidity.

Due to the high requirements on concrete quality and the contractor's lack of experience in making high quality exposed concrete, architectonic precast concrete first seemed as an appropriate solution. Different studies with companies specialized in precast concrete were made.
Two main limitations were met:

1 The new train station in Herstal, part of the 'Pôle Marexhe', 2016
credits: F. Dujardin
2 Axonometry of the 'Pôle Marexhe'
credits: MULTIPLE

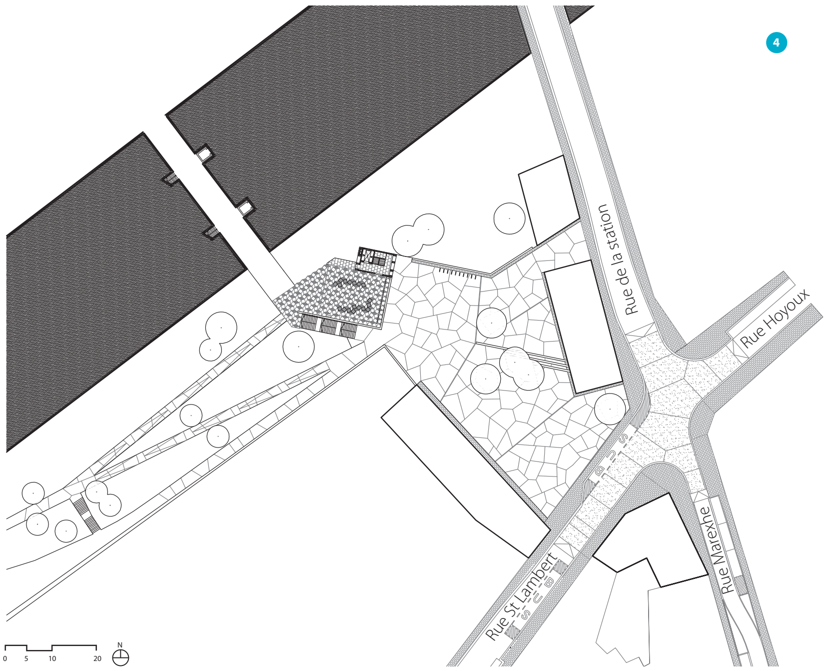
3

3, 5 The station is built in red self-compacting concrete with a raw texture imprinted by the timber formwork
credits: F. Dujardin

4 Site plan
credits: MULTIPLE

- The precast walls needed to have a high-quality finish on both sides. Due to production procedure of precast concrete element (i.e. horizontal casting), the companies could not produce massive wall elements that have architectonic finish on both faces.
- Due to the geometry of the tower (no intermediate floor on more than 9 m height), it would be very difficult to assemble massive precast wall elements and meet the structural requirements (i.e. the lateral stability).

Another solution was to produce sandwich wall panels composed of red architectonic concrete on both sides. These elements would then be assembled and connected by casting concrete between the two panels. This solution would easily meet the structural requirements. Unfortunately, the precast concrete industry is divided in two types of manufacturing companies. On one hand, the companies that make architectonic concrete do not build these specific structural elements. On the other hand, the companies that build sandwich wall panels could not meet the aesthetic requirements of the projects (architectonic finish and colour). In addition, the details (i.e. some angles and connections) would not attain the targeted level of quality.
Finally it was decided to use ready-mix concrete.



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6 Tests at the CRIC lab; determination of the colour and the texture
credits: J.P. Jasienski

7 Tests on self-compacting concrete:
(a) resistance to segregation,
(b) viscosity and flow velocity, and
(c) mobility and obstacles penetration
credits: J.P. Jasienski

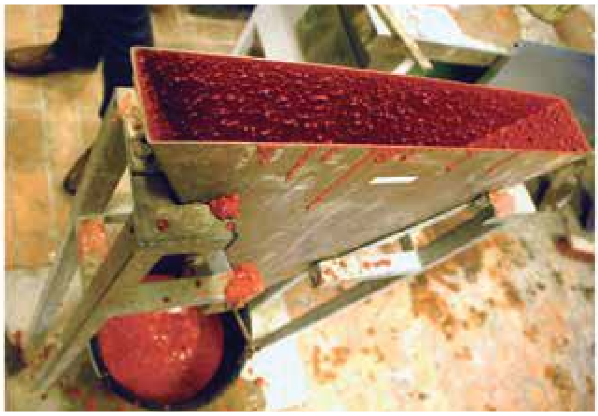

6a


6b


6c


6d


7a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7c

Second phase: definition of the composition of the concrete

The desired colour was intense and bright red. In order to reach this colour, different tests (both in the laboratory and on-site) were necessary. The first series of laboratory tests were mainly focused on obtaining a satisfying colour (photo 6). The different type of pigments, their percentage in the mix and the type of cement (white or light grey) were tested. Based on experience and literature (Lanxess, 2014), the percentage of pigment recommended before saturation is around 6%. In this case, it was fixed to 5.5%, which corresponds to one bag of pigment
(20 kg) per m^3 of concrete – a simple measure that avoids differences in production. This first test series helped to decide the exact pigment to pick (some were either too orange or too scarlet), but also the kind of cement. It appeared that the brightness of CEM III/B (light grey) and white cement were very similar and both satisfying. Therefore, the CEM III/B was further used.

The lateral faces of the station were textured. Different tests were carried out with polyurethane-elastomers form liners and wooden strips. The wooden strips were chosen due to their more 'organic' aspect and their ability to visually unify and 'correct' small imperfections in concrete itself (photo 6c and 6 d).

Results were still unsatisfactory due to bubbles at the surface. It seemed that the concrete was sticking to the formwork. Although the concrete was successfully fulfilling the usual tests (density, segregation and air content), the problem was not solved. Different types of formwork oils were tested but the results were still unacceptable.

In order to solve the problem of the bubbles it was decided to continue with self-compacting concrete. Moreover, considering the contractor's lack of experience, a self-compacting concrete appeared as a good way to minimize the impact of the concrete pouring on the surface quality. A simpler pouring method and the absence of a vibration process (the concrete self-places and self-compacts) were key points to opt for this kind of concrete. Tests with a modified composition including limestone filler (instead of fly ashes that would damage the red colour) were carried out to improve the self-compacting ability and the concrete surface finish.

8 The two 1/1 scale on-site mock-ups (a and b), and the resulting concrete, references for the reception on the further works (c and d)
credits: J.P. Jasienski

9 Inside view on the new Herstal train station
credits: F. Dujardin

Table 1 Main characteristics of the coloured Self-compacting concrete

Materials	quantity
- CEM III/B 42,5N LA HSR	380 kg/m^3
- Limestone Filler L	220 kg/m^3
- Water/cement ratio	0,50
- Red pigments	20 kg/m^3

Table 2 Tests executed in the labs and fixed values

Tests	values
- MVh – Density (NBN EN 12350-6)	2320kg/m^3*
- Concrete slump flow test – Abrams cone (NBN EN 12350-8)	660 mm T500 = 3,5 s No segregation*
- Air content (NBN EN 12350-7)	2,6%*
- Mobility and fill rate – L-box with 3 bars (NBN EN 12350-10) - Viscosity and flow velocity - V Funnel test (NBN EN 12350-9)	0,9 15,0 s
- Resistance to segregation - Stability at sieve (NBN EN 12350-11) % of laitance Bleeding after 15 min	 13 % no

* these measures were tested both at the concrete mixer plant and on the work site.

Due to lack of standards on self-compacting concrete, several lab tests were performed (photo 7) and used subsequently as base for the on-site casting (table 2).

Third phase: building site realization

Two 1/1 scale mock-ups were realized for three different purposes (photo 8). First to verify that the same specifications and quality of the approved samples made in the lab are still valid in real conditions (outdoor, bigger scale, ready-mix concrete from the concrete mixer plant, type of oil used for a formwork, resistance of formwork panels, setting the speed of the concrete pump…) and to approve the texture (soft and wood-textured) and the final colour. Secondly, to validate a reference that would stay on-site to serve as base for the further works. Eventually this was used to train the workers how to pour the concrete properly.

A strict building procedure was applied to avoid loss of quality:

- A clear process for the formworks was established. The formwork oil had to be applied within maximum 24 hours before casting, and the wood strips had to be humidified. It was assured that the formwork could resist very high pressure caused by the height of pouring (more than 5 m).
- The concrete had to comply to established tests and reference values (see Second phase - at the concrete mixer plant and on-site). The details of the delivery note also needed to be verified. The contractor had to work with a nearby concrete mixer plant to ensure the workability of the fresh concrete (less than 15 minutes in this case).
- During the mock-up tests, it appeared that it was better to set the speed of the concrete pump to the minimum and pour the concrete directly without any fall. Thus the extremity of the pump had to be always dipped inside the concrete. Since the handling of the head of the pump is not such an easy task, the same worker did the pouring for all the concrete of the building.
- A strict formwork stripping time of 48 to 72 h was defined through the mock-ups. This value had to be respected to secure the homogeneity of the hue.
- Due to different reasons (such as blemishes) some elements have been demolished and re-built on the building site. Their non-satisfactory aspect was easy to determine thanks to the mock-ups used as references and to the CIB scale of the standard PTV 21-601. For the main columns, an underestimated value of the pressure of the concrete (almost 6 m

8a 8b 8c 8d

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height poured at one time) led to deformations of the formwork that resulted in slightly bowed columns. The contractor eventually removed them and re-casted them with more reinforced formwork.

Conclusions

Through the case study of the realization of Herstal train station, this paper explained the methodology that was developed from the design process to the realization of the building to achieve a high quality and uniformly coloured self-compacting concrete structure.

Grand-Prix d'architecture de Wallonie 2015

The project was awarded Grand-Prix d'architecture de Wallonie 2015. The jury highlighted that the project aims to be both modest and very ambitious and sets a new frame for public spaces to support urban life.

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