1ST INTERNATIONAL ACADEMIC CONFERENCE

# PLACES AND TECHNOLOGIES 2014

**BELGRADE, 3-4. APRIL 2014** | KEEPING UP WITH TECHNOLOGIES TO IMPROVE PLACES

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Eva Vaništa Lazarević, Aleksandra Đukić,
Aleksandra Krstić - Furundžić, Milena Vukmirović

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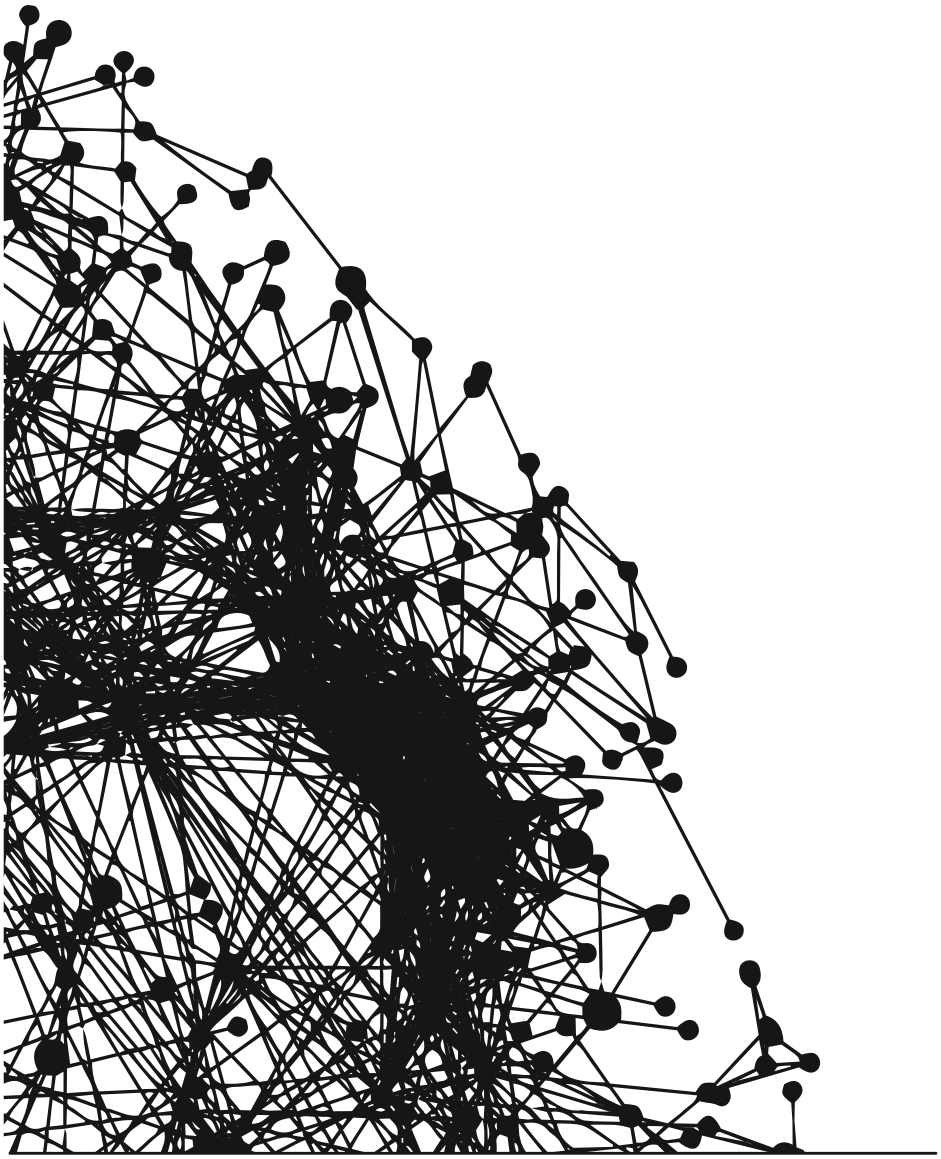

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# PLACES AND TECHNOLOGIES 2014

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# NEW COMPOSITE SLAB SYSTEM - LIGHTWEIGHT CONCRETE, STEEL SHEETING AND REINFORCEMENT

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## Abstract

*The construction industry is a vital part of the growth and success of a country. It is responsible for building the physical infrastructure that provides transportation and facilities for citizens, businesses, industries and institutions. Construction has a major influence on the economic wealth, societal well-being and sustainability of the built environment. This paper presents the structural behaviour of new composite concrete slab system with profiled steel sheeting and lightweight concrete fill. The system has potentials to become well accepted by the construction industry due to the many advantages over other types of floor systems. The slab is created by composite interaction between the concrete and steel deck with reinforcement to improve their bending resistant characteristics. Profiled steel deck performs two major functions that act as a permanent formwork during the concrete casting and also as tensile reinforcement after the concrete has hardened. The only additional nominal light mesh reinforcement bars that needs to be provided is to take care of shrinkage and temperature, usually in the form of welded wire fabric. Steel possesses a unique material property unrivalled by other materials in that it can be recycled both up and down the product value chain without degrading its structural strength and other chemical properties. Open loop recycling allows an old structure to be melted down, and then, when is recycled, it is re-melted to produce new appliances, structural beams, cladding and decking. Presented research focuses also on economic parameters of the topic, giving examples for some typical spans, in relationship with transportation needs, technology aspects and estimated time.*

***Keywords**: Lightweight Concrete, Steel sheeting, Reinforcement, Composite Slabs*

## Introduction

Sustainable construction refers to the adoption of building designs, construction methods and materials that are environmentally friendly. It also means using materials and resources that have sustainable supplies and are readily available from many sources (Namdeo Adkui Hedaoo). Through sustainable construction, we will do our part to optimize the use of natural resources via recycling and reuse of materials. This will also reduce our dependence on raw building materials, given the current disruption in the supply of concreting sand and granite.

Percentage share of the slabs in structural system, in terms of weight, time, and cost performance is at about 50%. This means that the topic of optimizing of slab system is very important in construction industry.

The maximum span length of single span composite slabs in contemporary use based on available steel deck floor in the market is around 6 to 9m. The choice of systems is very common because these systems can save construction cost and time. If the span length can be increased by a factor of, for example, 1.5 or 2, significant cost savings can be expected from elimination of some intermediate beams and their connections to the girders. These potential advantages have motivated research in the area of composite slab systems. In this case, long span slab systems that do not cause any significant increase in the depth and weight of the slabs compared to regular span slabs are particularly attractive. This has been one of the main objectives of the study.

## Discourse of composites of steel, light and reinforced concrete

Steel is an excellent reusable material. Independent agencies (and some steel producers) around the world have performed life-cycle analyses on the environmental impacts of using steel. Based on the results, informed designers can confidently specify steel products in their various forms for projects of all sizes, from single storey, low rise to high rise buildings. Steel can be recycled repeatedly without any degradation in terms of properties or performance in quality.

Steel has one of the highest strength to weight ratio of any construction material. Steel framing can weigh only one-third as much as traditional construction materials. When connected by fasteners, a steel frame is stronger than traditional systems. This provides savings in the foundation and to the amount of carnage needed on site.

## New Composite Slab System

The presented composite slab (Figure 1) is a mixed construction system made of worked steel sheeting, in which the appropriate reinforcements and the spreader mesh are put in order to avoid cracking due to retraction and temperature effects. Afterwards, the concrete is spilled. Further, concrete works jointly with steel taking

advantage of both materials. Further, there are lightweight concrete filling, with additional empty space, for MEP systems.

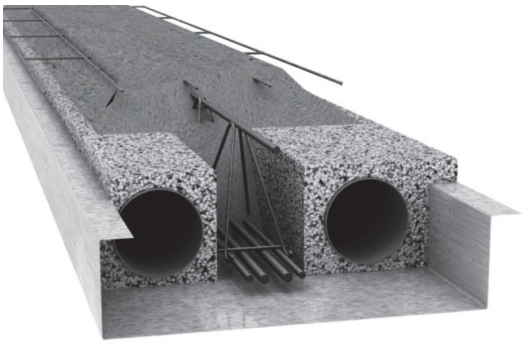

**Figure 48: Composite Slab System: Steel Sheeting, Lightweight Concrete Filling, Reinforced Concrete**

This system is specially designed for being installed over steel structures, though they can be used with concrete, wooden and masonry structures likewise, providing that the fixing and flange conditions are the optimum ones. It is suitable for a wide range of applications, such as:

- Industrial Buildings
- Offices
- Public Buildings
- Warehouses
- Department Stores
- Sport Centers
- Houses
- Garages

Major functions of subjected slab system are:

- Formwork
- Useful as a safe working platform
- Bracing structure
- Self-supporting weight and the overloading to which is subjected
- Facilitate the access to installations
- Acoustic and thermal insulation

Aimed and earned advantages are:

- Less own weight
- Avoid bracing
- More economic
- Facilities in stockpile
- Quick installation
- Does not pollute other materials
- Cleanliness

- Makes easier the movement of the building plants since bracing is not necessary.

In the current study, deep steel deck profiles are investigated (Figure 2). Two design phases have to be considered in the development of these new deck profiles for long span composite slab systems, namely the *construction* (non-composite) phase and *service* (composite) phase. The construction phase considers the strength and stiffness of the steel deck as a working platform that is subject to concrete self-weight and construction loads.

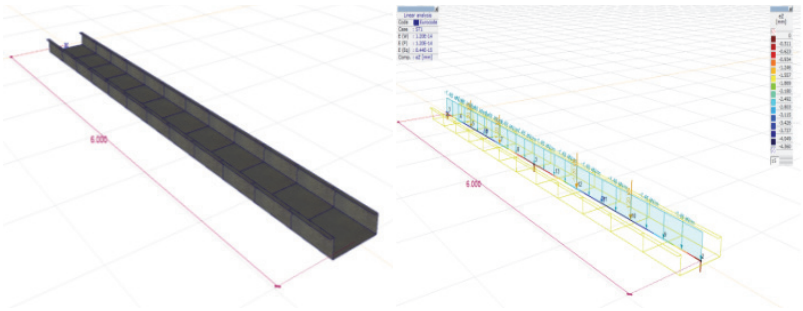

**Figure 2: Deep steel deck profile, MKE model and analysis**

This phase is important in the determination of the required deck stiffness. In the following it is shown that when a long span system is involved, the deflection (stiffness) limit state becomes very crucial (An L.). The service phase deals with a composite section of steel deck-concrete slab that is subject to occupancy loads.

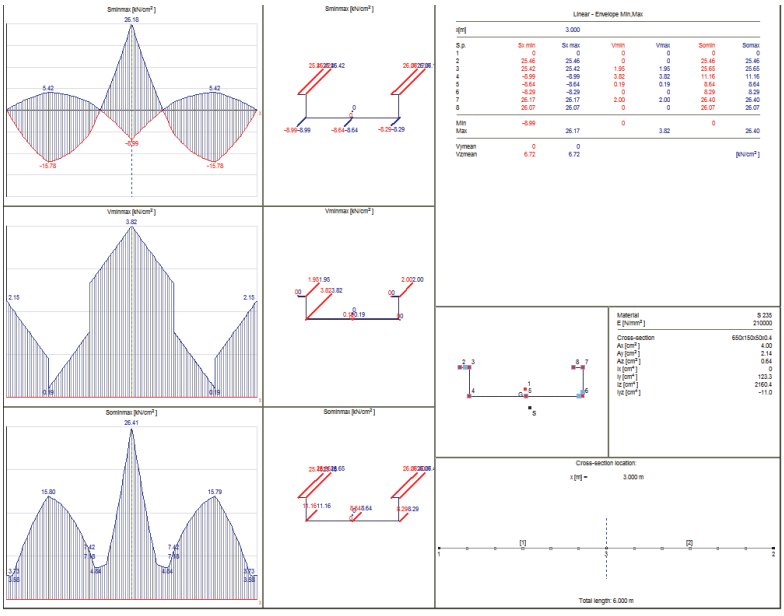

**Figure 3: Deep steel deck profile, Stress analysis**

## Construction Phase

As previously mentioned, this design phase considers the strength and stiffness of steel deck due to the fresh concrete weight. For typical span lengths, the flexural strength limit state is generally the governing condition in the design. For a longer span the governing condition is shifted toward the stiffness or deflection limit state. The steel deck weight was calculated based on the deck thickness that corresponds to the required moment of inertia for a certain span length with a given concrete self-weight plus the construction load.

## Exploitation Phase of the Assembly

In the service phase, predicted maximum loads of composite slabs can be calculated using various ways. The analysis was performed in the same ways as those with typical span length.

## System elements

Paper focuses on new slab system and presents the set of included elements. Basically, there are steel sheeting panels, profiled and designed for construction and service phase, lightweight concrete filling, lowering the weight of the package, and reinforced concrete rib, inside of the composite slab system. Beside of those, there are cardboard tubes, for additional lowering of self-weight, and for MEP system positioned under and throw the slab. Paper gives the scope of formwork elements, needed for production (Figure 4).

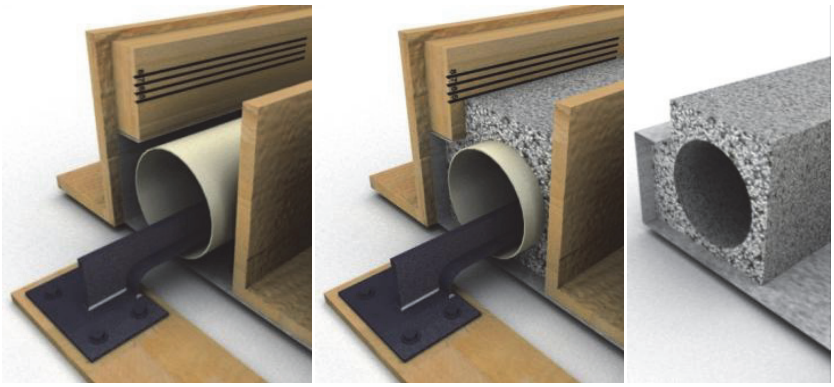

**Figure 4: Formwork and additional elements: a) Formwork, b) Lightweight fill, c) prefabricated element, prepared for transportation and erection**

System elements are designed to be lightweight, easy for handling, erecting and positioning on the site, but also to occupy less space on the production site, in transportation and, of course, on the construction site. (Figure 5)

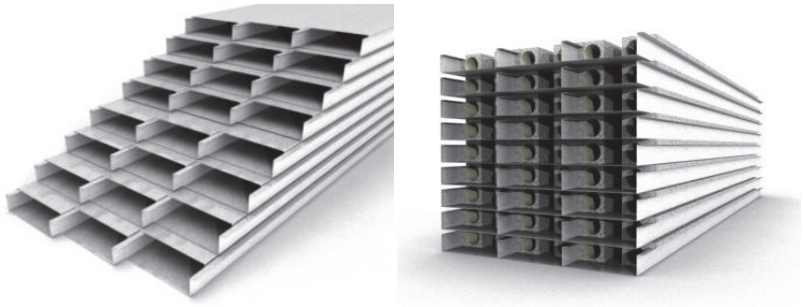

**Figure 5: Package of the parts, left: profiled steel sheeting storage, right: prefabricated slab elements storage**

Figure 6 shows the full range of elements, and Figure 7 shows the service stage of composite slab with flooring. Lightweight concrete gives additional insulating quality of the slab. Therefore, this system gives better conditions for floor heating systems in residential and public buildings.

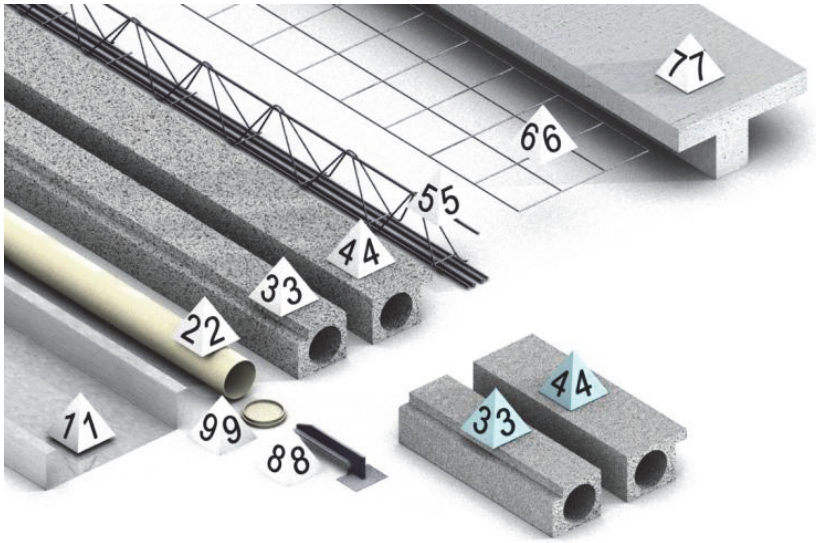


**Figure 6: Range of elements: 1) Profiled steel sheeting, 2) cardboard tube, 3, 4) lightweight concrete fill, 5) reinforcement, 6) steel mesh, 7) bearing concrete fill, 8, 9) additional accessories**

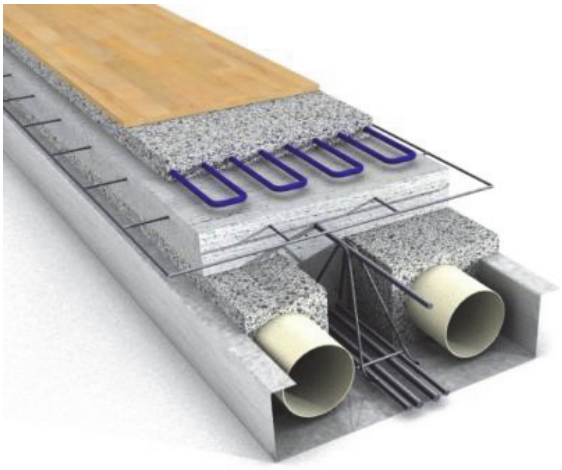

**Figure 7: Exploitation stage with floor heating and flooring.**

## Conclusion and directions for further development

Paper presented the new and innovated composite slab system which gives a plenty of optimal preferences. More than this function, is it opportunity for different materials to be used. One of the next goals is to develop the analogue system for wall partitions and façade sandwich panelling system. Figure 8 shows the first images of it.

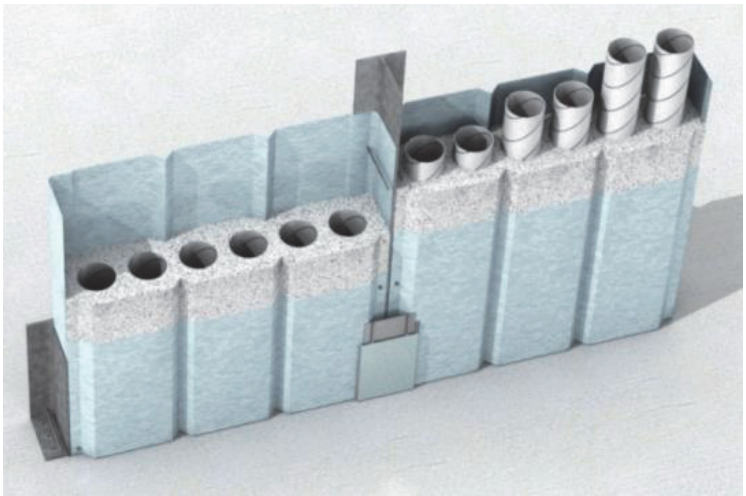

**Figure 8: Development of wall and façade panelling system**

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