HACBAC2025 | VI Congresso Ibero-Americano de Betões Especiais
Betão e Sustentabilidade

Faro, 18 e 19 de setembro de 2025

Reinforced concrete modular house construction with "tunnel" metallic formwork: benefits and obstacles

Alfredo Soeiro [(1)]

[(1)] Universidade do Porto, Faculdade de Engenharia, Portugal.

ABSTRACT

The description of the typical buildings using this technique is composed of solid concrete walls and floors. Buildings may have up to 20 storeys with heights up to around 60 meters. The concrete walls have continuity from top to bottom of the building in one direction or in perpendicular planes. The method of applying metallic formwork in the shape of an "U" presents the possibility of building a building floor each day. The "U" is composed of two "L" shapes put together at the top. The use of this technique allows pouring the concrete of walls and floor in about 4 hours for an entire half a day, generally after lunch, the cure of the concrete is done in the following 16 hours, withdrawing the formwork and placing the formwork in the upper storey in another 4 hours. The cycle repeats itself with a slab floor being executed each day. The area of each storey is generally a rectangle comprising as many apartments as needed. Elevators and stairs are built in a traditional way and represent the core of the building in terms of the structure resisting horizontal forces like wind or earthquakes. The utilities, like electrical, water and sewage installations are placed between the formwork before pouring the concrete and when this one is poured these are placed already in the walls and in the floors. This type of monolithic structures are easy to build in terms of labour and of equipment leading to cheaper and quicker construction. In an age of scarcity of affordable housing it may help reduce the society's difficulties in providing decent housing for everyone. The paper also addresses disadvantages, like the acoustic insulation, faced by this type of structure. Also the layout of each house raises architectural challenges due to the modular plan of each floor.

KEYWORDS: Reinforced concrete, modular construction, productivity, affordable housing, tunnel formwork.

1.- DESCRIPTION OF TUNNEL FORMWORK

Tunnel Form Construction Technique was invented in the decade of 1950, in France. It happened after the reconstruction effort due to the World War II destruction. It is based on metallic forms in a U rectangular shape with a certain length. It is commonly designated as a tunnel form. Frequently with the dimensions of a single room, these formwork elements allow walls and floors to be casted in a single pour. With multiple of these tunnel forms aligned in parallel, it is possible to pour an entire floor, slab and walls, of a building in a single concrete pouring operation. Thanks to a planned daily work cycle, builders can produce up to 400m² of floor area, with walls, every workday [1].

As shown in Figure 1, the tunnel is composed of two half-shells. Each half-shell consists of

a horizontal panel and a vertical panel braced by two struts. A stand with a sloped strut ensures stability, casters allow it to move and cylinders complete the adjustment possibilities. Positioning cleats and connecting pieces ensure perfect flushing of the formwork surfaces of several half-shells. A bottom panel can be fitted to the half-shells to cast a perpendicular wall, most of the time to act as a shear wall, to be casted at the same time as the walls and the slab.

Figure 1: Metallic formwork and supporting elements

Ties, rods, are placed to hold the plates of the lateral formworks in place. As it can be observed in Figure 2, to position the upper wall precisely, the starter formwork is placed on the halfshells before concreting. The primer to serve as a lateral support of the formwork is cast at the same time as slab and inferior wall. At each rotation of the set of tunnel formworks, the frames for doors, windows and hoppers are put in place. Same can be done with electric cables and water and sewage pipes. To allow proper positioning and fixing of these elements these are marked on the formwork. The rebars and steel reinforcement, mostly mesh wires, are also placed before casting the concrete [2].

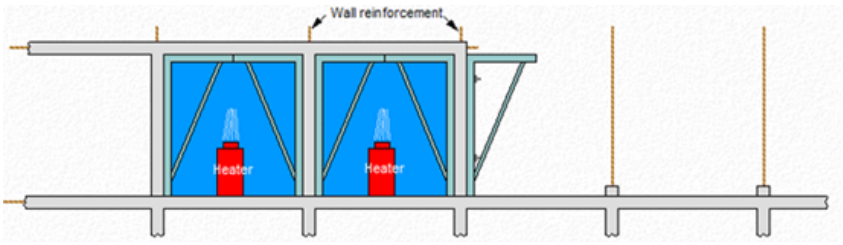

Figure 2. Schematic illustration of formwork positioning sequence and heating of spaces.

The use of tunnel-form produces monolithic structures. These are practically finished since surfaces of walls and slabs are plain and smooth. Operations, like plastering, can be eliminated as well as other wet trades like smoothing the concrete slab surface. It is basically an operation that involves casting walls and slabs in one operation in a daily cycle. Curing of the concrete can be accelerated with a protection at each end of the tunnel

by wrapping these with tarpaulins and by using butane heaters to maintain a sufficiently high temperature for the concrete to reach its striking strength overnight, as exemplified in Figure 2.

2.- ADVANTAGES

It is a construction method that allows rapid execution of building floors since walls and slabs can be poured in one day. The metallic formwork, the installation of electrical and hydraulic elements (slabs and walls), the steel reinforcement and the forms for doors and windows can be placed during the first half of the working day after disassembling the formwork from the immediate lower floor. This type of construction also requires less manpower due to the use of cranes and of planning of electrical and water/sewage infrastructures. A major advantage is the improvement of sustainability improvements since it reduces waste, consumption of materials, energy due to the mechanized process and complies with energy reduction due to the wall thermal insulation [3].

Then, the concrete does not require large amounts of steel reinforcement in the vertical walls, due to the large area of concrete subjected to vertical stress. Concerning the horizontal actions due to wind or to earthquakes there are many parallel elements with a long length. That creates eventual tensions in the concrete that are generally below the tensile strength of concrete. The walls that are perpendicular to the direction of the tunnel are generally built for the staircase or lift core nucleus and may need some steel reinforcement. As seen in Figure 4, the height of these buildings can range above 15 floors. Since the walls are built with solid concrete, between 15 and 25 cm, the thermal and external sound insulations comply with most norms and regulations [4].

Figure 3. Example of building up to 12 floors.

3.- DISADVANTAGES

A major obstacle is the initial investment due to the cost of this type of formwork. It is expected that the repetition of applications for this metallic formwork exceeds 500 times. Then the savings in manpower, in finishing works, in manpower and in steel reinforcements can be compared to initial costs and justify the options. It is a fact that many social housing around the world have opted for this solution from France, Portugal, India, United States, Egypt and Venezuela .

Another hindrance is the architectural restrictions due to the linearity of the supporting walls. Many architects dislike this construction method due to geometric implications in the flats layout. However, there are solutions that imply modularity and therefore simplification and efficiency. The architectural design must be planned for this system. Another known is the acoustic disturbance provoked by percussion in any floor that can be transmitted, due to the continuity of the concrete structure, to other apartments. Solutions have been created with floating floors and insulated walls with acoustic finishings, like cork panels [5].

4.- CONCLUSION

Looking to the actual and future of construction, this example of combination and possibilities of solid technology, of sustainable practices, of design modularity and of safety improvements, this may be one of the paths towards a more innovative and efficient industry. The potential for tunnel form systems holds tremendous promise, assuring us that the future of construction can be significantly improved. Surely, it presents a quick approach to provide cheap and generalized decent housing for current demands. It is a global challenge and this tested and proven technology can solve many societal bottlenecks.

REFERENCES

[1] OUTINORD, Tunnel Form System, https://outinord.net/tunnel-form-system/, accessed 26May25.

[2] Liang Gong Formwork, What is Tunnel Formwork For Housing?, https://www.lianggongform.com/What-is-Tunnel-Formwork-For-Housing-id48267726.html, accessed 26May25.

[3] Tejas, D. and Apte, M., Study of Advanced Tunnel Formwork System in High Rise Building, *IJRET: International Journal of Research in Engineering and Technology,* Vol. 5, n. 5, eISSN: 2319-1163 | pISSN: 2321-7308, 2016.

[4] Vallabhi, S. et al., Advanced Technology for Speedy Construction (Tunnel Formwork), *IJCRT,* Vol. 10, n. 4, ISSN: 2320-2882, 2020.

[5] Tezgelen, D. & Yilmal, Ö., Evaluation of user comfort in tunnel formwork housing areas: Izmir as a case study. *International Journal of Architectural Research*, 8, 10.26687/archnet-ijar.v8i1.315, 2014.