An Introduction to Bubble- Voided Concrete Flat Slabs

By

KAMRON SKAGGS

University of Cincinnati Class of 2017
EXECUTIVE SUMMARY

The idea of voided concrete slabs has been around for decades, and although designs may vary the premise behind them remains the same. More recently, the idea of cast-in-place bubble voided slabs has become a popular choice for designers and architects looking to decrease slab thickness and overall structure weight. This growing popularity can be attributed to the architectural need for longer spans and higher ceilings, more experience with and confidence in the product, and the push for sustainable design in the industry.

BODY

For centuries, structural concrete has been the material of choice for builders. The high compressive strength, ease of production and aesthetic component have driven engineers and architects alike to choose concrete on a multitude of projects. However, traditional concrete also has a few distinct disadvantages – namely poor performance under tension and a heavy self-weight. Because of these disadvantages, traditional concrete will require modifications in order to achieve many construction applications.

The idea of voided concrete has been investigated since the early 1900s [1]. In a traditional reinforced concrete slab span, the bottom portion will be in tension and therefore will require steel reinforcing to prevent failure. The top portion will be in compression, and the middle portion will effectively work only as a bridge holding the top and bottom portions together. In construction application, long-span slabs can become very thick and require large amounts of concrete. Concrete, weighing on average 150 lb/ft³, contributes greatly to the dead load encountered in a structure. Because of the mechanics in slab spans, engineers began to look for ways to remove the middle portion of the concrete while still keeping the slab intact.

To remove the middle concrete in a slab, voided concrete came about as a viable option for slab lightening. Traditionally, waffle slabs, hollow-core precast slabs, and single/double direction pan forming systems have been the most common voided slabs in the United States [2]. However, there are also disadvantages to these types of voided slabs that led to the development of the bubble slab. Waffle slabs and single/double direction pan forming systems will have lowered sections that remove headroom, which can be valuable depending on the needs of the owner (see Figure 1). These types of slabs will also require that the forms be removed and cleaned after installation and curing, while the plastic bubbles in bubble-voided concrete slabs are to remain encased in the concrete. Traditional hollow-core precast slabs will also require beams to bridge between the columns and provide bearing for the slabs.
The concept of bubble-voided flat slabs involves placing hollow recycled plastic shapes (typically spherical) in-between two layers of rebar, in the middle of a concrete slab (see Figure 2). Due to the replacement of concrete with air, the slab will have a lower dead load and therefore a higher allowable span – up to 55 feet without using beams [2]. The act of replacing concrete portions in the slab with plastic air bubbles will decrease the amount of concrete used, saving money and resources, as well as lighten the entire structure. Due to this smaller dead load, the columns and foundation will also decrease in size.
The performance of bubble-voided flat slabs compared to same-thickness reinforced slabs has been researched thoroughly in Europe. Tests performed in Denmark, Germany, and Holland revealed the bubble-voided flat slabs had a flexural stiffness about 90% that of a solid slab with the same thickness [3], while the shear resistance is 60% that of a solid slab. However, there is also a 35% weight reduction in the bubble-voided slab, allowing heavier applied loads than a solid slab. As shown in Figure 2, concrete cannot be removed from all locations in a floor slab. Due to punching-shear capacity, bubbles are not permitted near column locations.

There are two main patented ways to install a bubble slab in the U.S. The first, owned by Washington-based BubbleDeck, is similar to a precast filigree system. The bubble “cages” are assembled offsite and the first layer of concrete poured to secure the bubbles inside the cage (see Figure 3). Half-cast panels are then sent to the site, where they are placed and tied together with reinforcing. A second layer is then poured monolithically on top, creating a single flat voided slab [4].

![Figure 3: BubbleDeck filigree system.](http://files.armtec.com/Images/Categories/buildings-and-garages/Bubbledeck/BubbleDeck11copy.jpg)

The second method of installation, patented by Switzerland-based Cobiax, is a similar system that involves only field concrete pouring. Bubble cages are pre-assembled in 8 foot long bundles that are set in place for casting. The concrete is still poured in two lifts, the first to allow the bubbles to become partially cast in the concrete and the final to seal the slab together. Without performing two lifts, the bubbles have the buoyancy to float in the concrete and not remain in the middle of the slab [5].

Voided flat slabs are a prime example of the ingenuity among engineers that continues to exceed expectations. The concept behind these slabs is simple but has many benefits. By using
bubble voided flat slabs, one is able to decrease the dead load in the concrete and thus make the entire structure lighter, save money on construction materials, and achieve spans far greater than a standard slab. With recycled plastic being used and decreased concrete production, bubble voided flat slabs are the future of American sustainable construction.
References

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