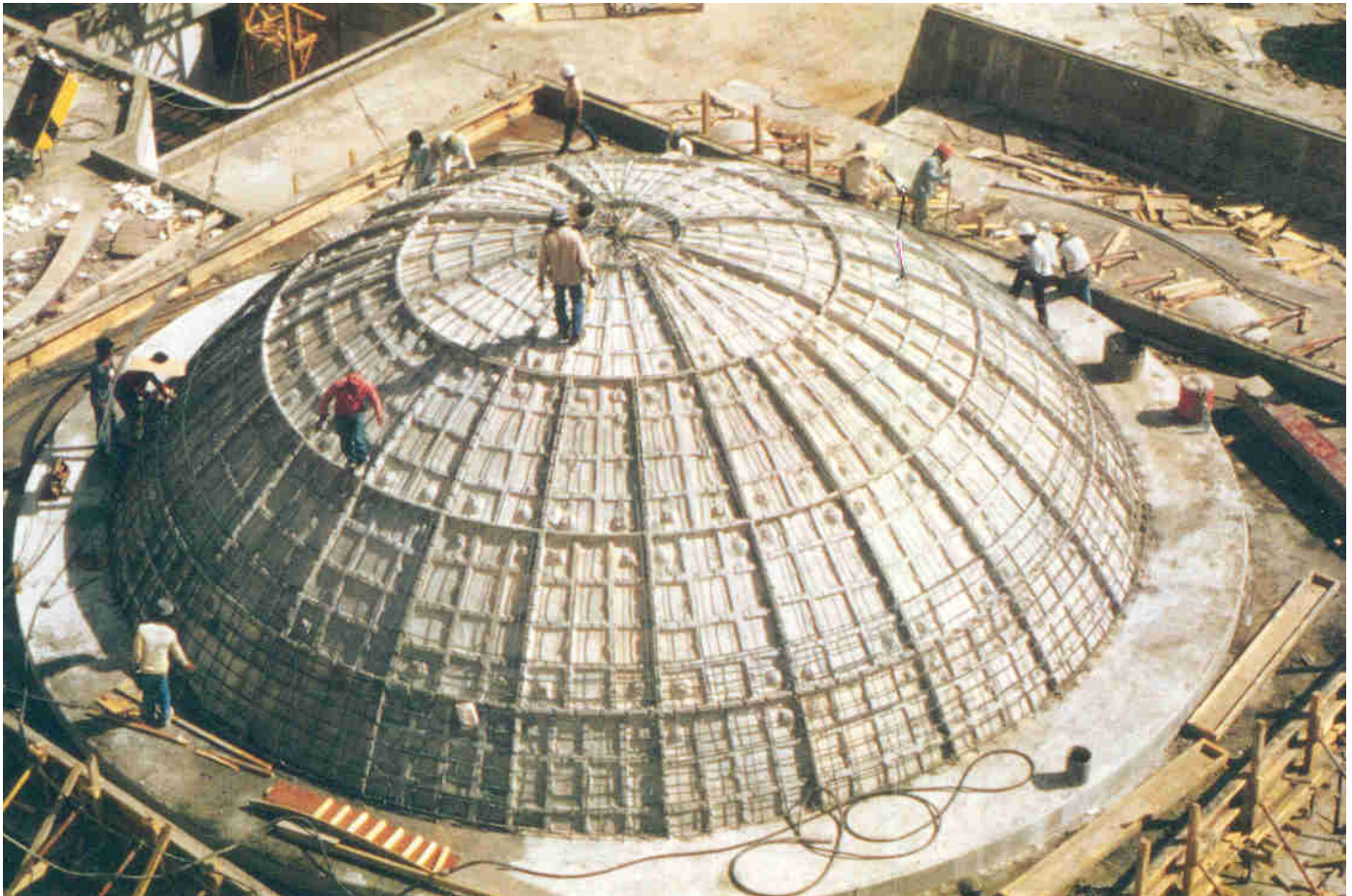




Cem-FIL® GRC Permanent Formwork

Saudi Ports Authority Headquarters



THE CHALLENGE:

The construction of a concrete dome is a complex building problem, and had been a relatively infrequent requirement, even in the Middle East. An interesting technique was developed in Saudi Arabia which led to more widespread applications.

In 1984 Eastern Corporation was awarded a contract to construct a prestigious new headquarters complex for the Saudi Ports Authority in Riyadh. The requirement for a 16 metre diameter dome in the main auditorium did not go unnoticed, but serious consideration of the problem was necessarily deferred whilst priority was given to detailed design and construction of the multi-storey tower blocks.

The architect's drawings specified a truncated spherical dome geometry and reinforced concrete shell. Construction methods were left to the contractor's discretion.

Good quality, spherically curved formwork is particularly expensive and demands a high level of skill from both craftsmen and site engineers. The main contractor was consequently interested to investigate the possible use of precasting techniques which, if practicable, could offer savings in both time and construction costs.

Local precast specialists Saif Noman Said (SNS) & Partners were already contracted to supply 30,000m² of prestressed flooring for the project, so their technical advisers, Hollow Core Systems, were requested to propose a solution for the dome.

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THE SOLUTION:

Early consideration was given by SNS to the possibility of pre-casting modular concrete components but this option was quickly discarded due to weight limitations and the available crane capacity.

A more promising solution appeared to be the adoption of lightweight Glass Reinforced Concrete (GRC) permanent formwork, used in association with a concrete shell. A design based on this concept was proposed by SNS and was readily accepted by the main contractor. SNS were subsequently commissioned for the work.

In principal, mould costs could be radically reduced by constructing a single, spherically curved, timber master mould only some 2 metres square to cast all necessary components. In practice several GRP impressions were taken from a negative timber master to provide higher panel production rates.

A segmental pattern of panel joints was adopted so that the dome formwork would require a total of 57 pieces, comprising five different panel types. Unusual care and mathematical expertise was necessary to determine panel boundaries and ensure accurate fit of component panels. Longitudinal joints presented little difficulty since these are circular curves in a single plane. Latitudinal joints proved to be considerably more complex since boundaries are curved in two planes and have variable geometry subject to position on the dome's surface. Templates were manufactured with precalculated profiles to assist correct location of stop-end forms.

The forms were designed as single skin units with upstand perimeter flanges and box section stiffening ribs to enable panels to support construction traffic and wet concrete loads. These were manufactured using standard spray techniques and given a conventional moist cure. The rib system assisted construction operations by acting as a permanent ladder for workmen on the steep side slopes of the dome.

GRC Panels, each weighing approximately 200kg, were handled with a site tower crane and erected on a concrete ring beam and falsework scaffold. Bolts were used to connect flanges of adjacent panels and stabilise the construction. All formwork was installed prior to placing reinforcement so that any minor adjustment to position could be made as necessary. Concrete operations were carried out by starting at a low level and working progressively upward toward the crown of the dome. Site construction work was fully completed within a two week period showing a significant time saving over conventional building methods.

The use of GRC as permanent formwork is a well established technique and had been used by SNS on many occasions. It is particularly suitable where single piece forms with complex geometry are required (10 small domes of similar construction were also provided to the Port Authority site in addition to the main dome). The 16m dome was a considerably more complex venture and it is believed to be one of the earliest uses of GRC in this application.

The success of this project introduced a novel technique for rapid construction of concrete shell structures and also provided a high degree of precision and finish quality at a competitive price.

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