

SPECIAL SEGMENTAL BRIDGE CASTING MACHINES

Venturing halfway around the world, EFCO Corp. agreed to engineer and manufacture pre-cast segmental casting machines for the world's longest viaduct. The viaduct, constructed in Thailand by Bilfinger + Berger, Ch. Karnchang and Dywidag Joint Venture (BBCD) was designed by J. Mueller International (JMI) in San Diego, California. The project not only involved advanced bridge designs, but the most sophisticated and state-of-the-art construction equipment. All parties involved with the bridge faced challenges:

- **Project Scale** - The viaduct was six traffic lanes wide (26 meters) and 55 kilometers long. Design called for the entire 6-lane roadway width to be cast in individual segments using the precast segmental method. Approximately 36,000 precast segments were required, making this project the largest of its kind ever built.
- **Construction Period** - In order to achieve the required rate of construction, the bridge, casting machines, erection equipment, and world's largest pre-cast yard had to be designed concurrently.
- **Signature Architecture and High Quality** - The viaduct was constructed over existing roadway through residential and commercial neighborhoods. The bridge's architecture was extremely important to the owner. Casting machines had to achieve the highest quality segments so that offsets and grout leaks did not mar the finished concrete structure.
- **Production Casting** - The casting yard required high production from the casting machines. Most machines were required to cycle daily. Considering the size, complexity, and quantity of segments, this was a remarkable achievement.
- **Variable Geometry Segments** - The architecture of the bridge did not permit exterior drainage of storm water. Water drained to the center of the girder where it was collected. This created a "reverse crown" geometry for typical sections transitioning to side drainage in the curves. This was handled through the bridge deck geometry. This unique requirement created imperatives for casting machine flexibility not seen on other projects with machines not only adjustable for super elevation, but changes in deck geometry.

To meet the challenges, EFCO applied state-of-the-art engineering and manufacturing techniques, years of innovative experience with casting machines, and new innovations to handle the size of segments, production requirements, and complex geometry. Innovations through the course of the work included:

- **Designing of Casting Machines** - EFCO engineering used advanced structural design programs and computers to make the most efficient structures. The structural analysis created engineered efficiencies for mass production of the equipment (48 machines) while controlling deflections to work within half the normal industry tolerances for deflections. Given machine complexities, EFCO engineers created two-dimensional and three-dimensional models of the concrete segments to design and detail the machines to eliminate interference from the various machine members during the cycling process.
- **Machine Innovations** - The three types of machines designed and supplied were for a typical casting, pier segment casting, and variable deck geometry casting. Each machine had its own variety of unique innovations to handle segment geometry, production, and durability requirements. All machines used some manual operations within the cycling routine, although most operations were performed hydraulically. The pier segment machine, with a complex interior form, used a combination of 54 hydraulic cylinders to perform the cycle.

Other innovations by machine type:

- **Typical Machine** - Combination of three core forms and carriers per machine to accommodate segment size production requirement and precast struts.
- **Variable Geometry Machine** - In combination with a machine to handle all job super elevation requirements, an adjustable geometry bulkhead methodology was developed and designed to manufacture segments where deck geometry would change from one segment to the next.
- **Pier Segment Casting Machine** - To handle a very complex segment interior that consisted of five large voids, a system of void forms, all hydraulically operated and moved together as a unit on one carrier was developed, designed and manufactured.

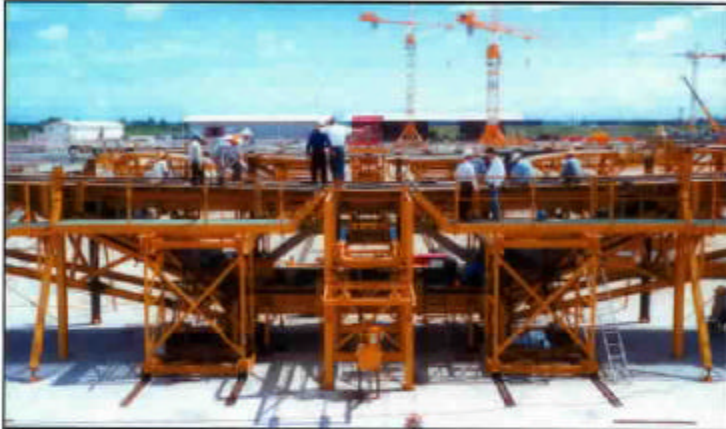
Other general innovations used across all machines included grout sealing for low maintenance and durability, tieless design, hydraulic systems, and the low profiling of the machines to bring them lower to the ground to impact labor requirements.

A number of major items were critical to project success. Partnering was done with the constructor and designer to design and fabricate casting machines while the bridge design and erection equipment design was underway. Success of this innovation can be measured by the short delivery cycle of the casting machines. BBCD contracted to build the bridge in August of 1995. The first segment was cast at the Bang Na casting yard in the first week of May 1996. Computer integrated design, detailing, and manufacturing of casting machines for segments of a size not production cast previously on a daily basis was done with some of the largest and most sophisticated machines ever designed and built. Hydraulic designs that permitted daily cycling of the casting moulds were some of the most complex relative to prior machinery.

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Casting machines supplied by EFCO
Bang-Na, Bang Pli, Bang-Pa Kong Expressway
Bangkok, Thailand



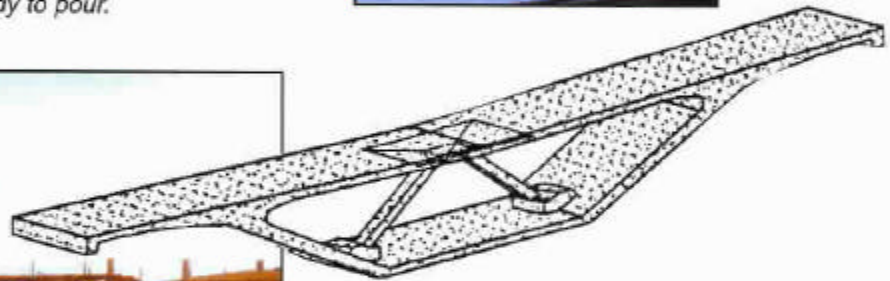
Typical casting machine closed and ready to pour.



3,500 workers and 78 casting machines form 40,500 precast bridge segments.



Pier segment casting machine.



Casting yard for Bang-Na, Bang Pli, Bang-Pa Kong Expressway is the largest in the world.



55 kilometers of elevated 6 lane expressway under construction in Bangkok.