Systems Building: Foundations

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My interest in systems building has been primarily related to industrialized building for the shelter industry. Foundations appear to be an afterthought and the most neglected portion of the industrialized building process. Heavy dependence on on-site labor, coupled with lack of standardization and dimensional coordination, appears to place foundation subsystems out of step with the industrialized approach. Building systems seem to be superstructure oriented.

At a national conference on foundations for systems building and modular housing in February 1971, speakers discussed systems building in general, the foundation subsystem, innovations in foundations and subfloor construction for light-housing construction, and the influences of code and factory housing law. Conference discussions revealed that the foundation system requires much more attention and study.

In light housing, the foundation used does affect the choice of materials for the subfloor. Therefore, major materials associations and industries have been busy developing foundation techniques and subsystems. There is some skepticism as to whether heavy construction, including bridge construction, can be truly systematized. Michael Praszker stated in regard to the systematization of soil engineering, "Use one soil engineering solution for two sites—I wish it could be so, but I will say it is not." Guy Rothstein checked with all the European high-rise concrete prefabrication plants and found that no research on the foundation subsystem had been undertaken because it was considered that the foundation problems were unique for each site. Jack Healy, on the other hand, has been working on a reduction of the myriad of foundation types to a limited set of subsystem types best suited for various foundation soil conditions on a worldwide basis. From an industrialized manufacturer's standpoint, Daly indicated that "the foundation remains the weakest point where we have made the smallest progress." Operation Breakthrough spokesmen echoed this when describing the program sponsored by the U. S. Department of Housing and Urban Development to revolutionize building processes and uses of material. They could not point to a single case where other than traditional foundation subsystems were used at the demonstration sites.

For systems building in general, Ezra Ehrenkrantz described programs where bids on construction are invited on a basis of other than cost alone; the ultimate objective is to invite a bid on the basis of cost plus time plus performance. On a "fast-track" approach, it may make sense to commence construction of foundations before the

Figure 1. Precast concrete bell piers used in Richmond-San Rafael Bridge in California.

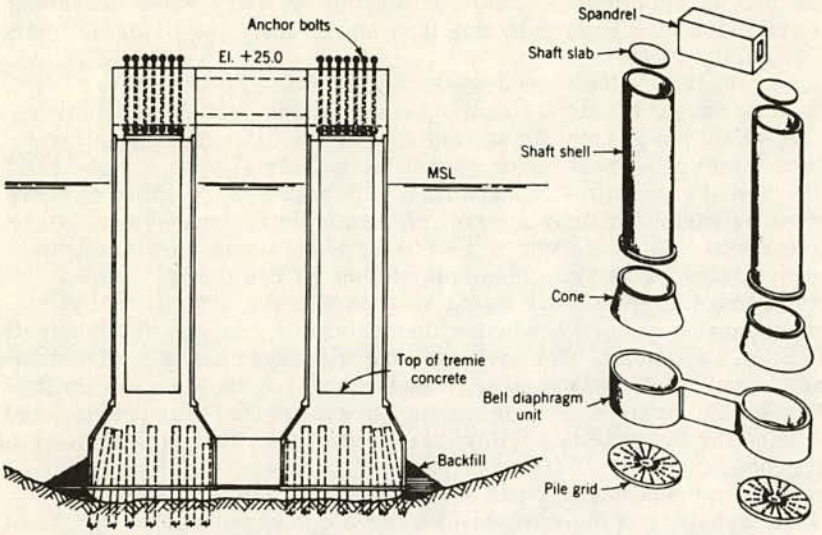


Figure 2. Sinking prefabricated bridge pier.

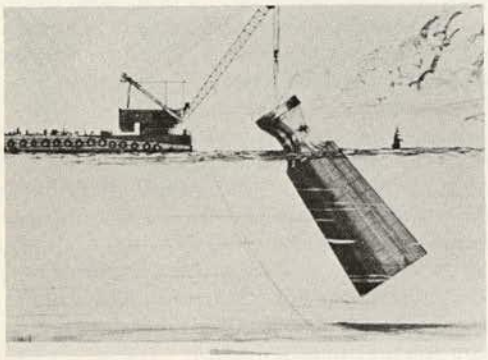


Figure 3. Yee's computer design approach.

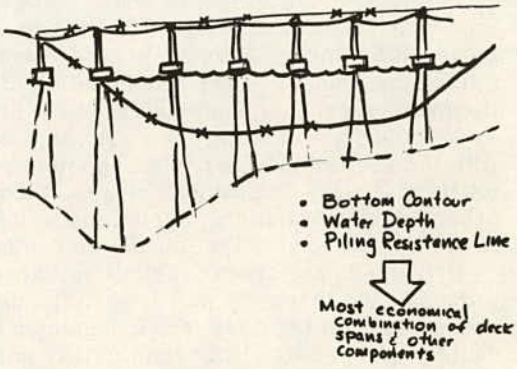
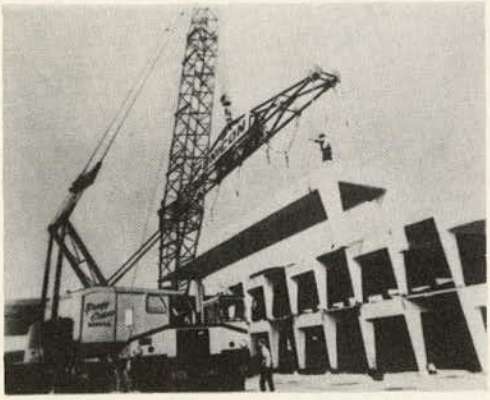


Figure 4. Unicon parking structure system.



superstructure is even designed. To take this approach for bridges would require considerable dimensional coordination. It could be feasible on many water crossings, such as Lake Ponchatrain and San Francisco Bay (San Mateo-Hayward Bridge), where straight, low-level trestles are used.

Guy Rothstein is a proponent of the closed-system approach. According to his philosophy, a single firm should handle the design, construction, and post-construction management. He would put present bridge building in the category of a tailor-made suit rather than in that of a ready-made suit of the industrial age. By contrast, the open system with modular coordination permits a wide interchangeability of components or subsystems by various manufacturers. An example of open-system usage is the bridge pile foundation subsystem where the pile cap acts as an interface component between various manufactured pile elements and the bridge pier. Various manufacturers today produce off-site stock items such as thin segmented steel pile shells or prestressed concrete piles. These are then brought to the site for integration into the bridge foundation subsystem. We have seen the increased use of prefabrication of larger and larger components. Only size and weight appear to be the main limitations. In the San Francisco Bay area, 900-ft continuous casting beds for prestressed concrete piles were used for the San Mateo-Hayward Bridge. T. Y. Lin described the process at the conference.

The move to larger prefabrication in urban areas has been primarily for water crossings where water transport to the site permits large components (Fig. 1). Lin described a proposed bridge between Alaska and Siberia where it is envisioned that a bridge pier, 300 ft high, is prefabricated at a site such as Seattle, towed to the site, placed upright, and sunk into the foundation soils. Post-tensioning cables are strung top-to-bottom with rock anchors at the bottom of the ocean (Fig. 2).

In the design or software phase, much is being done to speed up the bridge-building process. Increased reliance on the computer is in evidence. Alfred Yee, in a recent issue of Engineering News-Record, described the development of a means of determining the most economic combination of deck spans and other precast components. Computer input is a combination of the bridge site conditions (Fig. 3).

In the bridge industry, one area that could stand some improvement to keep pace with the shelter industry is the mobile or relocatable bridge, used mostly by the military (Bailey or pontoon bridges, for instance) at this time. The adaptability to urban bridges of building systems developed for relocatable multilevel parking garages is obvious (Fig. 4). The foundation can be utilized as a post-tensioning element.

Bridges do not appear to trail buildings in the use of the industrialized building process, and they may well lead in the use of large-scale prefabrication. The foundation subsystem is, however, a neglected link and requires more attention. Larger scale prefabrication has begun to take hold in the foundation subsystem with the accompanying simplification and reduction of the number of elements in the bridge substructure. Some of those attending the conference believe in the uniqueness of soil foundation conditions, or that problems at each site prevent a true systematization of the foundation. Others, including me, are working to truly integrate the foundation subsystem into the building system as a whole. This would appear to lead toward a reduction in foundation types, increased prefabrication, and a reduction in bridge construction time.