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BUILDING MATERIALS AND COMPONENTS

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A wide variety of building materials is used in both the United States and U.S.S.R.; but the smilarity is qualitative rather than quantitative. While in the United States each of the principal building materials has a large share of the market, in the Soviet Union many of the materials, some of which are the target of large research programs, make only token appearance in construction; and almost everything is built of concrete. In this respect the Soviet Union is more similar to the rest of the world than it is to the United States. Only the United States and Canada have a really free choice in selection of materials, and that choice is being restricted somewhat by the shortage of energy and the depletion of forests. In most countries materials other than concrete, the raw materials for which abound in all parts of the earth's crust, have become unavailable or uneconomical. As a result

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the United States does not rank in the top 30 nations of the world in the per capita use of cement, whereas the U.S.S.R. is in the top 10. Thus, in the Soviet Union the Ministry of the Building Materials Industry is virtually a euphemism for the cement industry. Although there is a commitment to revitalizing the lumber industry and part of the housing agreement deals with that activity, at the present time any review of Soviet building materials must be primarily a review of the cement and concrete industries. There has been large capital investment in both industries, and, given the Soviet penchant for research, in some very impressive research institutes which dwarf the corresponding facilities in the United States.

CEMENT INDUSTRY

The Soviet cement industry produces 120 million metric tons per year, a figure that in scheduled to be increased to 144 million tons during the current five-year plan. Capacity exceeds that in the United States by about 50 percent. Materials handling prior to burning in most of the plants is by the wet process rather than the dry process. In the wet process finely ground materials are transported hydraulically in a slurry. While it is a convenient way to move and proportion material, it is wasteful of energy since all the water in the slurry must be evaporated in the kiln. While the impact of the energy shortage has hardly been felt in the Soviet Union, there is a great deal of interest there, as there is in the United States, in converting wet process

plants to dry process plants; and this subject is the source of much conversation between specialists from the two countries. Although there is some emphasis in Soviet research in improved energy efficiency, both countries lag well behind western Europe and Japan in development of energy efficient plants.

In the United States there are four basic types of portland cement and two types of blended cement, those containing portland cement clinker blended with either blast-furnance slag or fly ash from coal-burning power plants. In addition there are a few optional variations to the basic cements and a small number of special cements such as shrinkage compensated cement. The U.S.S.R. industry has a somewhat more complicated structure. In addition to ordinary portland cement there is rapid hardening cement, at least two types of expanding cement, special cements for asbestos products, railroad ties, and seawater exposure, as well as a variety of blended cements, each available at several strength levels. However, because of limited storage capacity at plants and a continually pressing demand, particularly in the housing industry, specific shipments of cement frequently do not reach the intended consumer. Much of the potential sophistication in the system is lost when all the production of a plant goes to the local housing authority regardless of its intended use. This problem is distribution is readily conceded by plant personnel.

Cement plants tend to be large and to consist of well engineered mechanical equipment. Layout appears to be inefficient, and the sophistication of control is well below that found in the United States. In the newer plants in the US streams of raw materials are continuouly analyzed by an instrumental chemical analysis technique and the results provide input to valve or gate controls which automatically proportion the raw feed to provide the desired chemical composition. In spite of the emphasis placed on development of instrumental methods in Soviet research establishments, there appear to be no plants with automatic controls. Raw materials are analyzed by instruments, but proportioning in by hand. Soviet plants have not yet incorporated such energy-sawing devices as preheaters and flash calciners, which are commonplace in western Europe and Japan and are incorporated in most recent American plants, but they are being studied in research laboratories.

There are three principal research institutes in the cement industry. They are the NIIcement Institute in Moscow, the Giprocement Institute in Leningrad, and the Yuzhgiprocement Institute in Kharkov. In addition much of the fundamental work on which cement chemistry is based is carried out at the renowned Institute for Silicate Chemistry of the Academy of Sciences in Leningrad. A significant feature of each of the cement research institutes is a large well equipped pilot plant, which is the envy of all Amercan visitors. Equipment ranges from several small research kilns at the NIIcement Institute to nearly full-size kilns for the purpose of solving production problems at the other institutes. They

also have the capability for large-scale grinding studies. A large volume of research is carried out, running the gamut from colored cement to the rapid buring of clinker in a high energy electron beam in a linear accelerator, but relatively little of it seems to find its way into production technology. One area, however, in which significant useful work has been done is the chemical analysis by instrumental methods of clinker, cement, and hydration products. In most technical fields wet chemistry has been largely replaced by methods such as x-ray diffraction, x-ray fluorescence, differential thermal analysis, infared or ultiaviolet spectroscopy, electron spin resonance spectroscopy, and polarography. Several methods have been tried and are in common use in the American cement industry. In the Soviet Union, with the large investment in research facilities and personnel, all have been extensively investigated. A principal advantage to the U.S. of technical exchanges with the U.S.S.R. in this area is the availability of Soviet information on instrumental techniques.

CONCRETE INDUSTRY

Precast Concrete

In the program devised at the end of World War II to combat the colossal housing shortage in the Soviet Union, a commitment was made not only to concrete highrise construction but to factory produced precast concrete construction. The decision was based apparently on the

assumptions that factory production would provide the highest possible output per man-hour and that production could continue through inclement weather, particularly the long Russian winters. Everything is precast, including footings. As a result a concrete transit mixer is a rare sight on city streets in the U.S.S.R., although some do exist. Where a small amount of concrete is needed at a construction site, if is hauled in small round-bottom dump trucks. There are now in use two systems for constructing high-rise housing out of site-cast concrete, to be discussed later, but these systems provide for a small minority of total housing. For each such project a concrete batching and mixing plant is set up at the site.

A first impression of most American visitors to Soviet construction is the lack of concern for finishing. One common manifestation is the appearance of stairways in buildings other than highly-standardized housing. The stairways are precast, and frequently an integral number of stairs does not precisely match the story height. Hence, there is one odd-size rise either at the top or bottom of each flight of stairs. Exposed plumbing and wiring are commonplace. In American practice shoddy construction is frequently camouflaged by well-finished walls, floors, and ceilings. In the Soviet Union the reverse in true. Excellant construction from a structural point of view is made to look shoddy by poor finishing. This condition is surprising since in the expertise which has been developed for restoring czarist palaces and old churches it is evident that there is an appreciation for and an ability to create

good finishes. It may be that the appearance of mass-produced buildings is partly intentional in that the unfinished look connotes an air of urgency and an appreciation of the magnitude of the job to be accomplished so that those whose housing needs have not yet been met cannot accuse the authorities of wasting time and effort on unneeded frills.

The bulk of Soviet construction consists of multistory housing in heights for which bearing wall construction is economical and feasible. So committed are the Soviets to this policy that in many cities old single-family houses, which most Americans would find quite acceptable, are being systematically destroyed and replaced with the mass housing. As a result each major Soviet city has one or more housing factories, the so-called "kombinats" where exterior walls, interior walls, and floors of precast concrete are produced. Each such factory provides components for a particular system so that its products remain essentially unchanged for a number of years. There is, however, a considerable variety among the systems. Some systems have exterior bearing walls, some interior. The latter make possible low density exterior walls of good insulating properties with little concern for a structural strength. And lightweight concrete is produced by two entirely different processes; by the use of lightweight aggregat and by gas forming agents which produce cellular concrete.

The housing factories are highly mechanized and use assembly-line techniques wherby slabs or walls are cast in a horizortial position on moving beds which move through fixed stations where the operations of form preparation, concrete placing, finishing, curing, and form removal are performed sequentially. Curing is usually by atmospheric pressure steam at elevated temperatures so that the panels may be removed from the forms at an early age. Such a procedure decreases the length of the assembly line with a consequent reduction of capital cost. At the end of each assembly line doors and windows are installed in the panels, door and window frames are caulked, panels ae patched, if necessary, and placed in storage for truck shipment to the site. The concrete batching and mixing facilities are generally well run, and assuming that an appropiate type of cement in available, concrete quality is excellent. The problem again is finishing. The Soviets are reluctant to use an exposed concrete finish on exterior wall panels, partly apparently for aesthetics and partly because of concern that the fast moving factory production does not permit the care required for a good surface finish. It is common practice, then, to cast exterior panels with the outside down and to place an exterior finishing material in the form which subsequently adheres to the concrete. The most common is a series of 5 cm square ceramic tiles. They come with uniform spacing between tiles on a paper backing so tthat ultimately the space between the tiles is filled with mortar from the concrete. In practice local bond failures tend to develop between the tile and concrete and further damage occur during handling of the panels so that in fairly new buildings tiles are missing from the exterior walls.

The Soviets take seriously the insulation of exterior walls. It is accomplished by solid walls of lightweight concrete or by sandwich panels which may include two layers of normal weight concrete with a layer of insulation between them or a layer of normal-weight concrete adjacent to a layer of lightweight concrete. The Soviet Union has a large, well run lightweight aggregate industry with a capacity twice as great as that in the United States. The uses are considerably different in the two countries. In the United States more than half the production goes into concrete masonry units. Most of the rest is used in concrete, and it is a very common procedure to use it in floors of high-rise buildings as a means of reducing dead load with a consequent reduction of column size, and increase in rentable area. Neither of these uses has penetrated the Soviet Union. Virtually all the material is used in precast wall panels, for which there is an enormous demand. Because the Soviet interest is in insulation rather than structural strength, the Soviet material is processed to a lower density and lower strength than the American product. As is the case in the U.S. most of the Soviet production is expanded shale or clay fired in a rotary kiln. The Soviets have invested in some very large plants. Equipment both for production and control is excellent. The Soviets are expressing an interest in the use of industrial waste materials for lightweight aggregate. They apparently have not gone far with the development of expanded slag, as in the United States, or sintered fly ash, as in the United Kingdom.

Another technique for achieving low density in non-load-bearing walls is the use of cellular concrete. The material has found virtually no use in buildings in the United States although there are geologic applications where energy absorption is desired. The American practice is to mix a preformed foam with cement mortar. Cellular concrete for building walls was pioneered in Sweden where a process was developed in which a gas forming agent is mixed into small aggregate concrete, forms are partially filled, the concrete rises to a slightly oversize dimension as the gas forms, and the element is trimmed to precise dimension with a band saw. A similar process has been developed in Poland, and it is an integral part of Polish housing production. Its use in the Soviet Union is limited, but one large housing factory in Leningrad uses the Polish system for all its lightweight wall panels. While the panels have excellent insulation characteristics, that are fragile and easily damaged during handling.

Cast-in-place concrete

Inspite of the broard commitment to precast concrete, there are at least two industrialized housing systems in use which employ site-cast concrete. The first is the lift-slab system. In this system the columns are erected; then all the floor slabs are cast in a stack around the columns at ground level, with bond breakers between them. When they have achieved sufficient strength, the slabs are jacked into their final position in the structure. The system enjoyed some popularity in the

United States during the 1950's, but as new systems of forming and materials handling became available, it ceased to be economical. It has been highly developed by the Armenian Ministry of Industrialized Construction in Yerevan. The Armenian system makes use of precast concrete columns whereas in the western hemisphere steel columns were used. Most of the recent high-rise housing in Yerevan has been constructed by the lift slab technique. The warm dry climate in Armenian reduces the advantages of factory production. However, the Armenian Ministry has designed and supervised construction of several buildings, in most principal Soviet cities. The concrete that this observer has had the opportunity to see being placed in the slabs is of excellent quality. Once the columns and floors are in place factory produced precast wall sections are used to inclose the structures. The ministry is developing earthquake connections between columns and slabs for use in areas of high seismic activity.

The other cast-in-place technique tried by the Soviets is slipforming. At least one large high-rise housing development in Moscow has all slipformed walls. While slipforming is a standard procedure in the construction of structures such as grain elevators, only the most sophisticated builders have attempted it on buildings in the United States because of the difficulty in achieving a satisfactory surface. The Moscow development demonstrates some lack of sophistication in surface finish, but it appears structurally sound.

CONCLUSION

There is evidence that the housing shortage is easing. There are few instances of sharing of apartments by more than one family. As a result, authorities now seem concerned with customer satisfaction. Newly engineered systems provide larger units and better finishing. Some of the inflexibility of mass production, however, remains. The Olympic Village, for example, is a development of the most comfortable mass-produced apartments available. The overall effect is quite satisfactory. But there is a consistent error in each bathroom where it has been necessary to cut a notch in a wall panel to accomodate one pipe of a prefabicated plumbing unit. The error has been present for several years, but the press of production schedules has never permitted re-engineering the system to make the pieces fit.

In summary, the Soviets have engineered a series of multiple housing systems which through the years have shown progressive improvement from the initial small units with few amenities. Most have involved prefabrication. Components have been well designed and have contained high quality materials except in those buildings in which an improper cement was used in concrete. But because of the low priority given finishing, the resulting buildings have given an impression of poor construction. The easing of the housing shortage, with an attendant emphasis on customer satisfaction, appears to be having a salutary effect on the appearance of construction.