tons of high-priced structural steel, and substituted a like amount of scrap iron and steel to be mixed with the concrete, at a cost of only a few cents per pound. The utility of the structure was the same, the cost of construction much less.

A mechanical engineer designed an elaborate and expensive, but an ingenious and economical, set of cranes and devices for charging a reheating furnace and serving a steam hammer with ingots of a certain kind. It was afterwards found that it was not possible to work these ingots with that hammer. Here was a waste of money due to designing without having complete knowledge of the work in question. A few dollars spent on experimenting with the ingots in question with this hammer, would have prevented this error.

More than a decade ago a bridge being built in Canada failed owing to a pier sinking in the river as soon as the false-work was removed, owing to incomplete sub-surface surveys. This was a great waste of money due to faulty design of the foundation, based upon insufficient knowledge of the soil under it. Additional time and money spent in exploration would have prevented the failure.

Failure during construction does not always mean poor design. A few years ago an engineer had to build more than a mile of shore protection along a bay. He designed four types of walls and decided upon a design of concrete protection that was 50% cheaper than any of his other designs. He was severely criticized because about 200 feet of his shore protection failed, while being constructed under adverse conditions. Yet, this slight loss amounted to only a few hundred dollars, while he had saved more than $10,000 by the accepted design.

When the entire structure was finished it had ample strength to serve every purpose, and has proven this by some years of use.

Sewers are designed with many shapes, some of them extremely fantastic and expensive to build. Even with steel forms that are used over and over again for concrete sewers, some shapes make the cost of construction excessive. An odd shape does not add to the value of a sewer, but rather detracts from it, for the shape of the sewer should be designed for strength, available head room, and for the easiest flow of the sewage through it according to the gradient. This is also the case with conduits and aqueducts. If these considerations are followed in designing, then the costs are not likely to be excessive. When one considers the thousand miles of sewers that are needed in America, the need of an economical design of conduit is at once apparent.

Because concrete can be moulded into almost any shape, is not sufficient reason for making odd and expensive designs, not only in sewers, but likewise in any concrete structure. A railroad company asked for bids upon a number of concrete structures to replace stone masonry. The engineer had designed these concrete structures just as though they were built of stone, i.e., the wing walls had steps in them and the back of the walls and abutments had a series of steps and offsets varying from two inches to a foot, all of which meant extra costs for form work, adding nothing to the strength, as the same purpose would be served by a batter to the walls.

During the past year the writer made a visit to more than a dozen concrete bridges under construction, with a view to making economic studies of the work. It was quite surprising to note that only one engineer in designing his bridges had taken into consideration the methods of construction, and without sacrificing strength, had made his design so that thousands of dollars were being saved in construction, especially in forms. The centering timber used on one job had previously been used on three other bridges, to the superintendent's knowledge, and he stated that it was not new then. The cost of forms for concrete is always a heavy item. When their cost can be reduced it is the duty of the engineer to so design his structures.

This does not mean that graceful lines and architectural beauty should be excluded from the design. There can be ornamental panels, balustrades, columns and arches, as these structures are not only meant for service but to beautify. On the other hand, it is a waste of money to design and build ornamental panels, when they are to be covered over with vines, or the structures are so situated that they cannot be seen. A city once paid to have some bridges in a park made of ornamental design, only to allow their consulting landscape gardener to cover them with ivy. The ivy-covered bridges were pretty, but the costly ornamental panels were hidden, leaving only the graceful lines of the concrete bridges to be seen.

In designing structures the service of sewers, bridges and similar structures, is simple, i.e., they are for a single purpose. But it is not so with buildings and other edifices. Here the engineer must consider many things as regard to service, the problems being more complex. First of all, the purpose for which the building is to be used, should govern the lighting of the structure. The error in most cases is that of not having enough light, or having it enter at the wrong place or angle. Space that is too valuable may be given over to lighting, without obtaining the proper effect. At times the error may be to make the light too intense. These things apply to both sun and artificial light. A building to be used as a warehouse for storing goods does not present a difficult problem in lighting, but a school building, library, public hall, department store and factory gives the designer a very complex problem, and the success of the entire project may depend entirely on the lighting.

Money can easily be wasted in such cases. Few designing engineers and architects have given this subject study enough to solve such problems unaided, so they should call upon the services of expert lighting engineers, whose business is that of lighting alone.

In designing buildings for manufacturing, the various steps of the work to be done should be considered. The work should be planned first, and then the building designed to suit. Thus floors are generally built on the same level, while if different levels are used, chutes may carry the material from one machine to another by gravity, saving either machinery or the transferring by hand. The arrangement of rooms and floor space for machines should be in accordance with the sequence of the work so that material will not be handled unnecessarily. These arrangements should also be made in connection with the lighting system, for ample light means quicker and better work.

Store rooms for raw materials should be arranged at the place from which the material is to be worked up, and storage places for the finished products should be at the opposite end. This seems simple, yet it is a detail that is often overlooked, these store rooms being located with a view of easy handling, rather than for economical handling within the plant.