THE DESIGN OF GIRDER AND TRUSS SPANS AND TRESTLE WORK IN STRUCTURAL STEEL.

The present status of structural steel designing was discussed by F. W. Dencer, Chief Engineer for the American Bridge Company at the Gary, Indiana, Plant, before the Civil Engineering Society of Valparaiso University in a recent lecture. Many details of design were discussed for various types of structures. The paper in full is published in the Engineering Annual of the University and is here abstracted.

At the close of the last century, structural designing had reached, as it seemed to us, a very high stage of development. Yet in fifteen short years, many of the designs were relegated to the files, never to be used again. Bridge and structural designing had gone through a remarkable series of evolutions and who can say that we are nearing perfection? The chances are that in the next ten years the progress made in scientific designing will be as great, if not greater than the progress made in the last ten years.

Undoubtedly, many phases of designing will be better understood, as for instance, (a) the treatment of connections to resist secondary stresses, (b) the forces produced by impact of the drivers, (c) effect of temperature on initial stresses, (d) deformation of trusses, (e) action of columns under stress, (f) action of the top chord of through plate girder spans, (g) theory of bearing surfaces and proper materials to be used in their design, (h) use of stiffeners, etc. The speaker does not wish to convey the impression that these subjects are not understood, at the present time, but that further developments along these lines are possible and very desirable.

The tendency of the future in structural engineering, will probably be along the lines of standardization. That is, through the co-operation of various railroads, a uniform train clearance will be adopted, wheel loads for two or three different types of engines will probably be used, the steel material will be rolled to the same specifications and be of the same quality and finally engineers will agree on a uniform set of specifications for workmanship. Some attempts in this direction have already been made, as is evidenced by the work of the American Railway Engineering and Maintenance of Way Association in producing the specifications which are used by many railroads and corporations and also on the Common Standard drawings which are used by the Harriman Lines.

The engineering profession has depended on the following agencies for means for improvements in the past and developments to be made in the future: 1. Designers of railroads and bridge companies who are continually making use of new ideas based on the observation and action of existing structures. 2. Research work and investigations at testing laboratories and universities. 3. Discussions and papers of engineering societies. 4. Improvement in the quality of materials and the use of alloys.

Not many years ago, the longest angles obtained from the mills were 60 ft., to-day angles 125 ft. long may be obtained. Besides new sections have been rolled which permit of greater possibilities in designing, such as 8 x 6-in. angles, 24-in. I-beams, etc.

To show the importance of the quality of material in its relation to designing, it might be well to call attention to special materials which have recently (within the last decade) come into use and have served to revolutionize existing methods of design.

Cast steel, because of its high tensile and compressive strength and its adaptability to conform to different shapes, is used quite extensively for bearing boxes, shafts, shoes and bearing bolsters. It is used often for details where heretofore castings were prohibitive. A small quantity of aluminum is commonly added to the cast steel. It permeates through the entire mass without artificial stirring and adds to the ductility of the steel as well as preventing blow holes.

Because of the high price of cast steel, engineers were forced to design a great many details of rolled steel which from the standpoint of strength and good designing, was inferior to the cast steel designs. In recent years, the price of cast steel has dropped and engineers are using cast steel more extensively. The new Municipal Bridge of St. Louis just erected has chords of nickel steel.

Metallic nickel, nickel ore, or ferro-nickel to the extent of 3½ per cent. of nickel is added to the bath of steel made by the open hearth process. The nickel increases its density, elasticity and strength. The high elastic limit of nickel steel tends to prolong the life of the metal and because of its superior toughness, offers greater resistance to sudden strains and shocks.

Phosphor bronze, a combination of tin, copper and phosphorus, is used for bearings which are subject to high pressures and run at slow speed.

Lumen metal manufactured and patented by the Lumen Bearing Company is also used for bearings. It contains zinc, copper and aluminum. The advantages claimed for this metal are its light weight and low coefficient of friction.

Other alloys of varying proportions and metals are used for frictional surfaces, the most common of which is babbitt metal. It is composed of lead, tin, zinc and antimony. For high speed metal the base is tin, and for low speed the base is lead.

Manganese steel is used for purposes where an extremely hard metal is required, as for rail locks, frogs, or switches. The material is too hard to cut with a tool and must be ground where a finished surface is required.

Improved processes of making and rolling structural steel have enabled engineers to design structures with a higher degree of efficiency for the same weight. This statement must be taken within certain limits, due consideration must be given to the greater deformation caused on the material when the ultimate stress, and consequently the working stress, increases per square inch.

The use of alloys and special materials is mentioned briefly to show that their uses have much to do with the progress made in designing. In other words, many details that recently have come into use would be impossible were it not for the scientific progress made in steel manufacturing.

As this paper will deal principally with designs for the most practical details, we will attempt to show that many details can be simplified and made more practical without impairing their strength and often with better results.

The best design of structure is one which has the smallest number of members to resist the stresses, also each member designed with a minimum number of component parts, provided, of course, that due consideration is given to the proper distribution of the material. In other words, the simplest design is the best, other considerations being equal.

Girder Spans.—The depth of a girder is generally taken as the economic depth. This can be determined by expressing the weight of the girder in terms of the unknown depth. Frequently the depth of the girder span is determined by other considerations, such as the base of rail to masonry being fixed or to make suitable connections to adjoining spans.

An important step is to decide on the "building up" of the top flange. To avoid dapping of the ties, some railroads use four angles with side plates between. This method leaves the top flange clear on top without and projecting rivet heads or cover plates. The bottom flange is commonly made up of two angles and sufficient cover plates, the weight of the cover plates being about equal to the weight of the angles.