Structural Engineering.*

In designing any structure it should first be considered as a whole and afterwards in detail. This may seem to be an unnecessary admonition and one that would always be followed as a matter of course. Unfortunately this is not so, and too great a consideration of detail is sometimes allowed to mar the excellence of the whole. A design should be looked upon from an economic standpoint, as a sound piece of engineering construction and from the aesthetic point of view also: These considerations have been placed in the order in which unfortunately they are of necessity considered. This being an utilitarian age, the question of cost not only enters largely into, but frequently governs the design, the cheapest design being usually followed, provided that it fulfills the essential engineering conditions. The design is a good specimen of the engineer's handiwork, usually comes second into considerations and sometimes good patterns must be sacrificed to the first great consideration — economy. The aesthetic standpoint is unfortunately the last and quite frequently does not seem to have been one from which the designer has considered his work at all, in fact it may be said that, usually only on very large structures does it enter into the design to any appreciable extent. When it is considered that almost all structures built are required to fulfil certain conditions at the minimum cost, it is not to be wondered at that general designs, outlines and details are largely fixed by the dictates of dollars and cents. The number and length of spans in a crossing are usually fixed by the minimum cost, the main dimensions of a truss are determined largely by the maximum weight, and the details are designed and often standardized so as to render necessary the least labor possible in construction. The conscientious engineer will always endeavor to make his design conform as closely to the best engineering practices as the conditions under which he is working will permit. The aesthetic side of designing also should not be lost sight of, the appearance of a bridge may sometimes be greatly improved by a slight alterations of outline, shape of gusset plates, design, especially in deck bridges, but this artistic standpoint of designing must be carried out in harmony with the general engineering design; cheap ornamentation tacked on to a good design with which it does not harmonize is rather an eyesore than an ornament. An arch harmoniously designed is probably the most pleasing structure that can be erected, although some of our suspension bridges are certainly works of art as well as monuments of engineering. The curved top chord of a truss almost always adds as much to the beauty as to the economy of a bridge. The material of which a structure is built has a great effect on its appearance. The general design should harmonize whenever possible with the surroundings. The relation of height and width of piers should be considered together with the length of the supported spans. Long heavy spans harmonize with heavy broad stone piers, while narrow steel towers and bents go better with short spans. A vertical longitudinal curve in a bridge produces a pleasing effect, and should be provided on all those of any great length. A structure may have very little ornamentation and yet be very pleasing to the eye on account of its inherent beauty and apparent suitability to the purpose for which it has been designed.

In a bridge the general design should be as nearly symmetrical about the centre as conditions will allow, the general outline should please the eye. Clearness of purpose should dominate the design, "eternal fitness of things" should be evident, that is, the various members of a structure should indicate from their appearance the function they perform towards the whole, they should showfitness for their work, a compression member should appear as massive as possible and a tension member with equal stress should have a much lighter appearance, those of greatest stress should appear so, for example, the diagonals of a truss should diminish in side elevation from the end towards the centre of the truss. The design should be such as to provide the shortest path for the stresses to pass to the supports, also to equalize the stresses in similar members so far as possible. The details should be so designed as to reduce the shop labor as much as possible, and so as to be of greater strength than the main members.

The highest quality to strive for in a design is simplicity, from the purchaser's standpoint the simplest design is the best; from the manufacturer's standpoint it is the cheapest. The structure should be simple, so that the path of stress is known and so that its amount may be accurately calculated, the joints as few in number as possible and detailed so as to be cheaply and easily constructed, both in shop and field. The action of the various members of the general design should be assured, so that one member will not be called upon to do the work of another which it was never intended to do. There should be no ambiguity as to the path of stress through the various details. The exercise of good judgment enters largely into successful designing; although the stress produced by the specified exterior loads may generally be accurately calculated, it is quite often necessary to proportion members and details much larger and stronger than the specification calls for, as in the case of laterals for railroad bridges, which quite often are more necessary to take up vibration than to withstand the specified wind loads; stiffness also demands larger sections in members sometimes than the stresses would indicate. The working lines of stress in a member should coincide with the centre of gravity of the section of the member, and all such lines of members coming together at a point should intersect in one point as far as practicable. Members of a truss, etc., should be symmetrical as far as possible about two planes, one lying in the plane of the truss and the other at right angles to it. In designing, the work of the erector should not be lost sight of, joints should be so made as to cause a minimum amount of field riveting, the rivets should be so placed as to be easily driven, the joints should be

* Paper read by E. A. Stone before the Nova Scotia Society of Engineers.