the following experience of the writer's shows that good results can be maintained after the hardest work.

The 2,000-kw. Willans-Parsons set installed at Hylton Road was tested on setting to work, and again on the expiration of one year and two months' work, during which time the plant ran over 9,000 hours, and generated over 9,000,000 units. The steam consumption on a 27½-in. vacuum was 17.07 lbs. of steam per unit on one test, and 17.1 lbs. of steam per unit on the other.

As regards oil, which was logged separately from the other plant, the total cost for the year ending March last was for the turbine, $67, and for the turbine auxiliaries, $92, a total of $159, equivalent to 0.000953 of a penny per unit generated. It would be difficult to claim such a record of maintained economy for any prime mover other than the steam turbine.

CONCRETE BRIDGE SPECIFICATIONS.*

By T. H. Macdonald, Iowa Highway Commission.

It is clearly an impossibility to present anything approaching a complete set of specifications in a paper that would not be tiresome to the auditors and unfair to the other numbers on the programme. I shall, therefore, attempt to touch only a few of what we consider the more important considerations, general and specific, relating to concrete and its use in bridge construction.

The first requirement of any set of specifications should be its ability to defend itself in any court of law, if permissible to express it in this way. That is, a specification should first of all be legal, which would mean the entire absence of catch phrases or the uncommon use of words or phrases that could be construed to the disadvantage of either party. Technical terms and phrases must, of course, constitute a large part of the text, and yet it is possible so to construct them that if read before a jury of twelve men, the meaning and general fairness of the various clauses would be apparent if the finer technical distinctions were not.

This may be well illustrated by the attitude taken by a capable engineer who uses a certain method for determining earth work. This method is not as accurate as some others but he justifies its use because it is easily demonstrated to and understood by a jury as ordinarily made up. It is questionable how long any specification will stand before a jury if the actual facts do not substantiate it.

A second important requirement is the practicability of the methods outlined. It is undoubtedly poor practice to write exceedingly stiff specifications if there is no intention of carrying them out practically as written. There probably never has been a piece of work where little adjustments did not have to be made from time to time as the work progressed, but this does not necessarily mean that the specifications were not practical. And there are also clauses which are included only to be used in the event of certain contingencies. For instance, we specify that no concrete shall be dropped more than three feet while being placed in the forms, but this specification is not strictly enforced unless concrete is being placed in thin sections or in water.

Specifications should also be definite to enable the contractor to know just as nearly as possible the grade of material he will be expected to furnish and the amount of work he will have to do, together with as much other accurate information of this character as possible. For instance, we try to specify the exact elevation to which the contractor will be required to carry his foundations at the price bid, and allow an extra for concrete placed below this elevation.

For large bridges, standard specifications will not prove applicable without the addition of many specific clauses but for smaller structures, particularly for concrete slab culverts, general specifications can be used that prove fairly satisfactory for covering the work of a township or a country. A table has been prepared and is included herewith which shows the thickness, the amount of reinforcing in square inches per foot of width, the stress in the concrete and in the steel for culvert slabs from two to twenty feet clear span. The loading used is the dead load which includes the weight of the concrete and the earth fill plus a concentrated live load of twelve-ton traction engine mounted on axles, eleven-foot centres, the rear axle carrying a weight of eight tons.

The classes of concrete to be used in these structures are as follows:—

For the tops: Class A concrete.

For the side and wing walls: Class B concrete.

For the foundations and footings: Either Class B or class C concrete.

The following is our standard specification for classes of concrete:—

Classes of Concrete:—The concrete shall be designated by classes which shall be proportioned as follows:—

Class A. concrete:—1 part cement, 2 parts sand, 4 parts broken stone or screened pebbles passing 2-inch ring.

Class B. concrete:—1 part cement, 2½ parts sand, 5 parts broken stone or screened pebbles passing 2½-inch ring.

Class C. concrete:—1 part cement, 3 parts sand, 6 parts broken stone or screened pebbles passing 2½-inch ring.

Sand Content:—Unscreened gravel may be used for classes B. and C. concrete, subject to frequent tests by the engineer to determine the sand and pebble content, and in no case shall the sand be greater than the class requirements or less than is necessary to fill the voids in the pebbles.

Class B. mortar:—1 part cement, 2½ parts sand passing ¼-inch mesh.

The approximate quantities for a cubic yard of concrete of the above proportions are as follows:—

Kind.	Cement. Barrels.	Sand. Cu. Yd.	Screened Pebbles, Broken Stone. Cu. Yd.
Class A.	1.57	0.44	0.88
Class B.	1.25	0.46	0.92
Class C.	1.10	0.47	0.94

Note:—"It shall be permissible for the inspector to slightly vary the above proportions of sand and aggregate for the different classes to secure a denser concrete with the materials used."

It will be noticed that we do not adhere strictly to the exact amount of aggregates in the various classes where the materials can be used to produce a smoother concrete by slightly adjusting the amounts as given. The class C concrete is the weakest that we use and at the present price of cement we believe it is false economy to use a leaner mixture, except in very heavy construction, and even then we prefer a fairly rich concrete with one man rubble stone imbedded in this concrete. The division line between sand and gravel is placed at about a No. 8 screen. The advisability of following the specification in regard to determining the sand and pebble content is well illustrated by the following table, which reports the results of tests made on sample sent in from various counties:—

Gravel.	No.	Pebbles per cent.	Sand per cent.
Greene Co.	1	80.8	19.2
Greene Co.	2	46.3	53.7
Greene Co.	3	34.3	65.7
Greene Co.	4	43.0	57.0
Greene Co.	5	57.1	42.9
Carroll Co.	1	33.8	66.2
Story Co.	1	58.7	41.3
Story Co.	2	47.3	52.7
Story Co.	3	42.4	57.6
Emmet Co.	1	65.2	34.8
Emmet Co.	2	30.4	69.6
Emmet Co.	3	51.7	48.3

*Read before the Iowa Cement Users' Association.