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OF GENERAL INTEREST

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RECENT DEVELOPMENTS IN THE USE OF CARBON, HEAT TREATED, HIGH STRENGTH BOLTS

BY T. R. HIGGINS*

(Presented at a meeting of the Structural Section of the Boston Society of Civil Engineers, held on March 14, 1951.)

SO MUCH has been written in the past one hundred years concerning the strength and efficiency—in short, the design—of riveted and bolted joints, that it would seem little more could be added now. De Jonge, in his "Bibliography on Riveted Joints", lists references to over 1200 published articles dealing with the subject, all of them appearing prior to 1941; the first entry, being a report of the Committee on the Explosions of Steam Boilers, published by Franklin Institute in Philadelphia in 1837.

However, one does not have to dig very deeply into the literature before becoming impressed by the preponderance of material which is almost entirely of a speculative nature. So often the author starts out by making a number of more or less arbitrary assumptions as to how the several components in a particular joint behave under load—what the distribution of stress would be treating some part of the joint as a free body. These assumptions may be close to the true conditions or they may be very wide of the mark; more often than not there is little if any experimental data by which to prove or disprove their validity. Hence, the starting premise being clouded in uncertainty, the conclusions at best are little more than speculation of a doubtful value.

In recent years better instrumentations have made it possible to employ methods in experimental research not available to earlier investigators. In the light of these developments, about four years ago a number of technical bodies, interested in obtaining a better under-

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standing of their actual behavior, organized the Research Council for Riveted and Bolted Structural Joints. Like the Welding Research Council and the Column Research Council, this new organization, upon the recommendation of the American Society of Civil Engineers, is sponsored in part by, and functions under the auspices of, the Engineering Foundation. Other contributing sponsors are the:

Association of American Railroads
American Institute of Steel Construction
American Iron and Steel Institute
Illinois Division of Highways
Industrial Fasteners Institute
Public Roads Administration

In addition to the financial support of the above mentioned bodies, substantial contributions of intrinsic value have been made by the universities in whose laboratories the experimental programs are being carried out, namely at:

The University of Illinois
Northwestern University
The University of Washington
Purdue University

Cash disbursements out of Council funds to date for the purchase of specimens and to defray the actual cost of laboratory testing, have totaled well over $100,000. If all indirect contributions, such for example as the personal time contributed by the several members of the Council, were to be reckoned in, the total value of the effort to date would approach a quarter of a million dollars.

The Council's overall program of investigation has been divided into some eight separate projects. While these projects are closely inter-related, nevertheless each is concerned with no more than one or two aspects of the overall problem.

I shall confine my remarks to the work of Project IV, which is concerned with the use of high strength bolts. I do this for two reasons. In the first place, the work which has already been completed under this project seems, at this time, to offer the greatest promise for improvement in the efficient use of steel construction. In the second place, the Council at its Annual Meeting on January

31st last, adopted a recommended specification governing the use of these bolts which undoubtedly will be of considerable interest to structural engineers. The Council felt justified in doing this based upon the evidence already at hand, even though the full research program is by no means completed. Later perhaps some revision of the recently adopted specification may be in order; in the meantime, however, the recommendations which have been made are believed by the Council to be on the conservative side. In view of the interest which has been displayed in the use of this new technique, and the volume of construction which has been scheduled using it, it had become imperative that some controls be established.

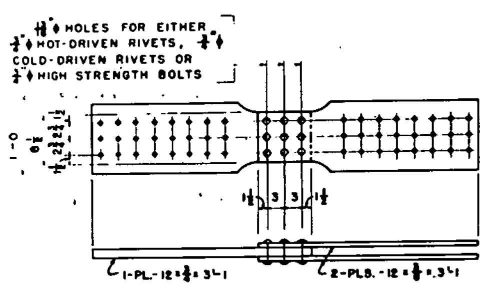
A notable feature, distinguishing the experimental work which is being carried on by the Council, from experimental work of earlier investigators, is the extensive use of fatigue testing in the Council's program. Machines large enough to perform fatigue tests on full-size joint specimens containing more than about four usual-size rivets or bolts have been developed only in the past decade. Exploratory work which had been performed on these machines, prior to the formation of the Council, had already indicated that this method of testing is often the most effective approach in comparing the behavior of joints of differing design. Two joints of slightly different geometry, which may exhibit nearly the same behavior under static loading, often prove to have very different endurance limits under many repetitions of cyclic loading.

Much of the structural steel which is fabricated and erected in this country each year—in fact a preponderance of it—will be subjected to but a relatively small number of cycles of maximum loading during its entire lifetime of service; so few in fact that, for all practical purposes, the service condition may properly be considered as that of static loading. Nevertheless, there are numerous examples of structures, dynamically loaded with a sufficient number of cycles of widely fluctuating applied loading, so that the criterion of usefulness of the structure is its endurance against fatigue failure. Some parts of most bridges, and all parts of some industrial equipment come within this category. If, through extended research, sufficient knowledge can be acquired so that joints with superior endurance properties can be designed at little if any increase in cost over present practice, the question of whether a particular structure actually will be subject to fatigue loading becomes somewhat academic. If no material increase in cost is involved, most engineers, and the owner for whom they are making a design, would prefer to employ the practices known to provide the tougher joint, even on framing which definitely will be confined to static loading.

As compared to those made with both hot-driven and cold-driven rivets, joints of similar pattern in which properly installed high-strength bolts have been substituted for rivets, have consistently exhibited superior behavior under fatigue loading. Quantitatively speaking—in kips per square inch—the difference in unit stress at failure under a specified number of cycles of loading may be small or it may be substantial, depending upon the joint design.

According to the working stress recommendations of the American Association of State Highway Official's, the American Railway Engineers Association's and the American Institute of Steel Construction's recommended design specifications, a "balanced" design would be one where the unit shearing stress in the rivets or bolts was .75 of the unit tension or compression stress on the transverse (stressed) area of the connected parts of a joint.

The joint under investigation in Figure 1 consists of the square



AREA:	TENSION	= 4.50	SQ. IN.
	SHEAR	= 7.96	SQ. IN.
	BEARING	= 5.06	SQ. IN.

TENSION : SHEAR : BEARING RATIO = 1.00 : 0.57 : 0.89

DETAIL OF SPECIMENS FOR FATIGUE TESTS

FIG. 1.

pattern of nine rivets connecting the two 12″ × 3/8″ outside plates to the 12″ × 3/4″ inside plate. The open holes in the widened ends of the specimen are used for bolting it to the testing heads of the fatigue machine.

Since the nine rivets will be loaded in double shear, the total shear area is 7.96 sq. in. Comparing this area with the net tension area presented by the cross section of the middle or two outside plates, it appears that the rivet shear area is 1.76 times the plate tension area. In other words the unit shear stress will be $1/1.76 = .57$ times the unit tension stress. Likewise the unit bearing stress will be .89 times the unit tension stress.

This joint does not represent a balanced design as judged by the unit working stresses recommended by any of the three previously mentioned standard design specifications.

According to the AASHO and the AREA specifications for bridges, the tension : shear : bearing ratio of a balanced design would be

$$1.00 : 0.75 : 1.50$$

According to the AISC specification for buildings, the corresponding ratio would be

$$1.00 : 0.75 : 2.00,$$

differing from the bridge specifications only by the relative intensity of the allowable unit bearing pressure.

Comparing the ratio actually employed in the specimen shown, with these recommended ratios, it will be seen that such an excess of rivets has been used that one could expect all of the test failures to occur in the plates, rather than in the rivets. Such proved to be the case in all of the 24 tests in this series.

Figure 2 is a schematic picture of the fatigue testing machine in which the 24 tests were run. The upper horizonal beam is pivoted on an upright fulcrum post. As the right-hand end of this beam, or loading lever, is pushed up and pulled down by the action of the eccentric

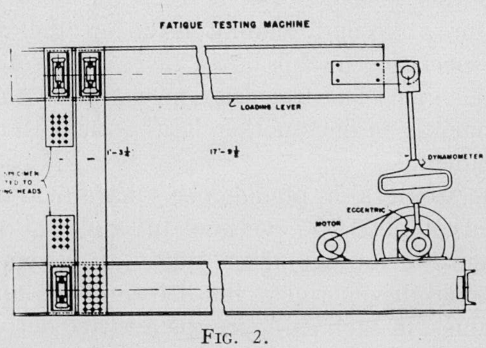


FIG. 2.

cam on the drive shaft, the specimen bolted to the testing heads to the right of the fulcrum post is alternately stressed in compression and tension, or, by an adjustment of the length of the crank shaft, can be alternately stressed from zero to maximum compression, or zero to maximum tension. By adjusting the throw of the eccentric cam, the magnitude of the compression or tension load on the specimen can be increased or decreased. The actual value of this load is obtained by Ames dial measurements of the deformation of the dynamometer.

The equipments used in this series of tests is really two machines, as is evident in Figure 3. In the foreground one of the test specimens

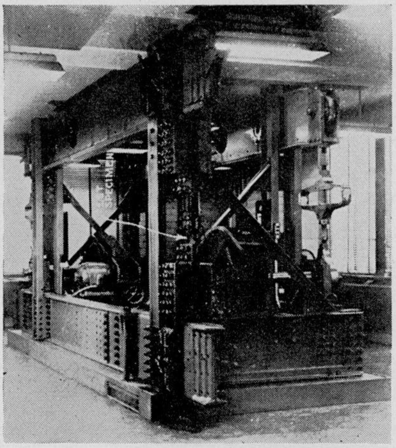


FIG. 3.

may be seen mounted on the near (left-hand) side of the machine. To the right of this specimen can be seen the drive mechanism and dynamometer for a second loading lever on the far side of the machine. The specimen, in this latter case, is out of sight at the far corner of the machine. The two drive mechanisms and loading levers operate independently of one another. Either or both can be operating at any given moment.

The fatigue strength, in pounds per square inch of net transverse plate area, based on 2,000,000 cycles of full reversal of cyclic loading, is given in Figure 4 for the three types of fasteners used in this series of tests: cold-driven rivets, hot-driven rivets and high strength bolts. These values, in each case, are the average derived from several

FATIGUE STRENGTH OF FABRICATED JOINTS	
TYPE OF FASTENER	FATIGUE STRENGTH AT 2,000,000 CYCLES AT FULL REVERSAL
COLD-DRIVEN RIVETS	14,700 LB. PER SQ IN
HOT-DRIVEN RIVETS	15,820 LB. PER SQ IN
HIGH-STRENGTH BOLTS	17,200 LB. PER SQ IN

FIG. 4.

individual tests in which the loading cycle was varied from $\pm$ 15 to $\pm$ 20 ksi of plate stress.

It has been found that, if

$S_{2,000,000}$ is the fatigue strength of a plate stressed 2,000,000 cycles of full reversed loading; S_t is the magnitude of the cyclical test load; and N is the number of cycles of loading required to produce failure at that test load, the fatigue strength at 2,000,000 cycles may be expressed empirically in pounds per square inch, as

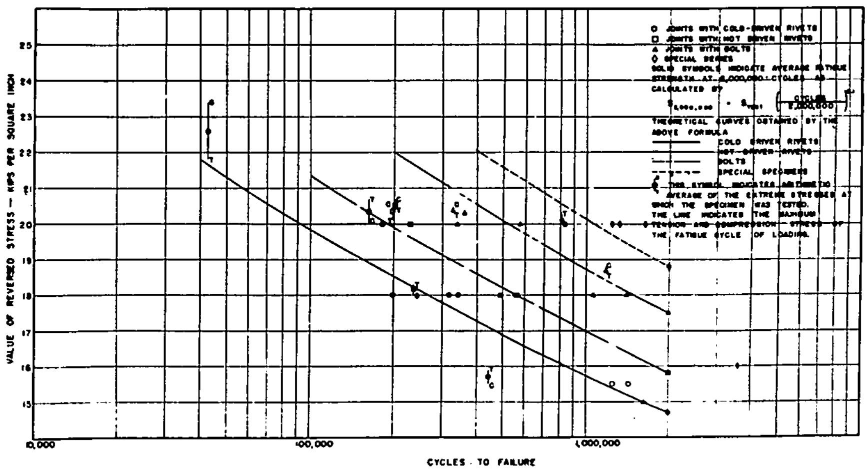
$$S_{2,000,000}, = S_t \left[\frac{2,000,000}{N}\right]^n$$

where the exponent n is an experimentally determined constant, the value of which is dependent upon the geometry of the test specimen.

Reasonably good correlation of the data obtained in this series of tests was produced using a value of 0.1 for n, as may be seen from Figure 5. Reading from left to right, we have the S-N curve for the cold-driven rivet series; the hot-driven rivet series; the corresponding high strength bolt series; and finally a second and somewhat different series of high strength bolted joints.

The average clamping force in the several bolted specimens represented by the third S-N curve from the left, varied, from slightly above bolt yield point stress, to as little as 60% yield point stress. This variation in clamping force strangely enough, seems to have had relatively little effect upon the fatigue strength exhibited by the several test specimens.

Also it appears to have had very little effect upon the amount of slip observed in the several joints tested. This slip was so slight (in no case being more than 0.001 in.) that it may be considered as negligible. It was, however, less for the bolted specimens than for either the hot- or cold-driven riveted specimens.



Test Results Compared to Computed S-N Curves.

FIG. 5.

The S-N curve at the extreme right covers the results of a later series of bolted joints in which a 12″ × ⅜″ middle plate was substituted for the typical 12″ × ¾″ plate used in the earlier tests. These thinner middle plates had three holes drilled in transverse lines to match the earlier pattern. However, bolts were installed only in the four outside corner holes. This produced a tension : shear : bearing ratio of 1.0 : 0.64 : 1.80, which is more nearly that of a balanced design. Note that, using this more ideal stress ratio the average fatigue strength at 2,000,000 cycles was raised to 18.8 ksi, instead of the 17.5 ksi noted for the less balanced series of bolted specimens.

It is also interesting to note the nature of the failure in this latter series of tests. In each case a crack started at opposite sides of the middle hole, in which no bolt had been installed. From this point the cracks extended outward towards the edges of the plate. But in each case these cracks skirted out around the corner holes containing bolts. The open center hole, as might be expected, produced a strong notch effect; the clamping produced by the bolts, in the remaining two holes on the so-called "net section", appears to have not only wiped out the notch effect of these holes, but seems to have made the "net" section stronger than an unpierced section immediately in front of the filled holes, where the cracks appeared. This is a phenomenon which has been observed in a large number of

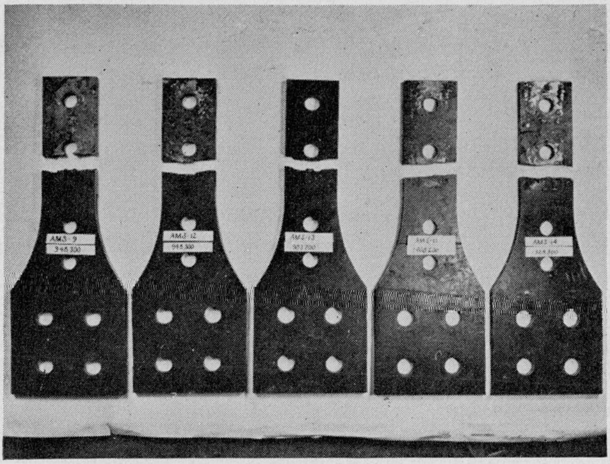


FIG. 6.

the fatigue tests that have been run on specimens assembled with properly installed high-strength bolts.

Figure 6 shows one half of five, two-bolt, lapped specimens, tested in a load cycle of $\pm$ 16.0 ksi stress in the lapped plates. Note that in every case the failure occurred outside of the so-called "net section." These plates were of course subject to bending as well as direct stress, due to the eccentricity produced by their lapping. In spite of this combined bending and direct stress, the five specimens averaged 1,123,000 cycles of $\pm$ 16.0 ksi direct stress loading before failure. The slip per cycle here in no case exceeded .0006″ and the cumulative slip for the full number of cycles of loading in no case exceeded .002″.

The fact that the tension : shear : bearing ratio in this case was 1.0 : 1.0 : 1.37, indicating an inadequate number of bolts as judged by usual design practice (yet in no case was the test failure in the fastener) illustrates the superior behavior of the high strength bolts themselves as compared with ordinary rivets. Had rivets been used in this series of tests they undoubtedly would have been the cause of the test failure.

In the tests so far described, the maximum slip in both the riveted and bolted joints has been of a very minor order—that of the bolted joints being slightly less than that of the riveted joints. In all of these tests however, the loading applied to the specimens was, if anything, slightly less than that required to produce the full allowable shear stress on the nominal rivet and bolt areas, when these shear stresses are calculated in the usual manner. In the case of the bolted joints of course, no actual shear stress is experienced by the bolts. The holes were drilled 1/16 inch larger than the nominal bolt diameters and the slip was far too small to bring the side of the holes into bearing against the bolts. There is some experimental evidence (at least in the case of thin plates) that this freedom from bearing may contribute to the superior fatigue strength of the connected plates. Obviously, it is beneficial as far as the bolts themselves are concerned, since it precludes the possibility of stress in them due to bending moment. For all practical purposes, the stress in these bolts is nearly a non-fluctuating (static) tension stress, producing no fatigue.

The very fact that clearance around the bolt exists however, makes the question of slip one which must be studied. In many types of structures a slip of 1/16 inch, required to bring the several connected plys and their fastening bolts into bearing, is of no serious consequences.

It has been common practice for many years to use ordinary unfinished bolts in holes having a 1/16 inch clearance for most of the field connections in Type 2 framing, as that type is defined in the AISC Specification. Occasionally however, slips approaching 1/16 inch in magnitude cannot be tolerated, if basic design assumptions are to be achieved in practice.

In such cases, it would appear advisable therefore, to have a factor of safety, over and above usual unit working stresses, for the stress at which any major slip in these bolted joints is likely to occur.

As a part of the Council's program of investigation into use of high strength bolts, a number of static tests have been performed at the University of Washington, to determine the equivalent unit shear stress at which the first major slip is likely to take place in joints using high strength bolts. Several variables have been investigated in this program, to wit:

1. The amount of tension in the bolts.
2. The condition of the contact surfaces of the connected parts.
3. The amount of contact surface per bolt used.

The solid line graph in Figure 7 shows the average slip of three bolted specimens against the corresponding average bolt shear value, calculated on the basis of the nominal shear areas of the bolts.

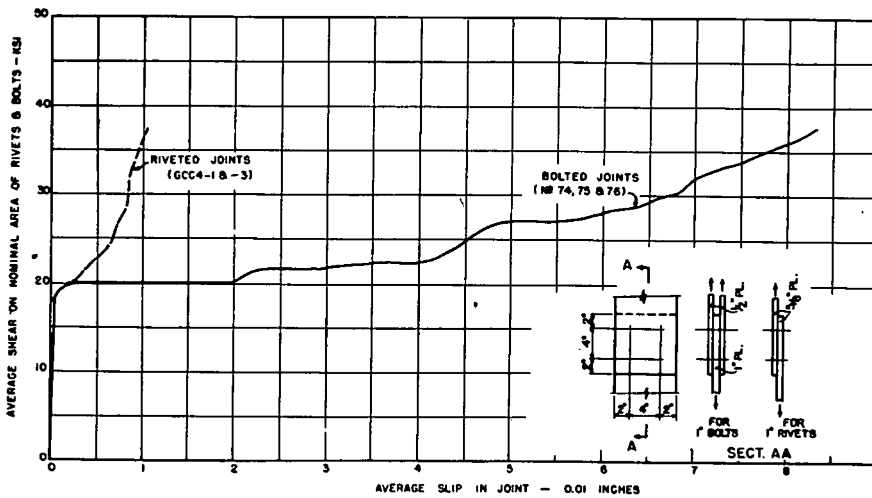


FIG. 7.

These average slips are compared with the average slip of two nearly similar hot-riveted joints reported by Professor Wilbur M. Wilson and Mr. Frank P. Thomas in Bulletin No. 302 of the University of Illinois Engineering Experiment Station. The significant differences in the two types of specimens were the type of fastener used and the number of shear planes per fastener. In the case of the bolted specimens, the bolts were in double shear; the riveted specimens on the other hand, were in single shear.

One other difference perhaps might be noted, having to do with the method of measuring the slip. In the case of the bolted specimens, Ames dials were used to measure the total amount of differential movement between the inside and outside plates, at both edges, midway between the two transverse rows of bolts. In the case of the riveted specimens, the slip was measured by means of a tapered pin which was inserted in a small hole drilled through both connected plates approximately at the center of the rivet pattern. The distance which this tapered pin could be pushed into the hole, after an increment of load had been applied, was the measure of the slip effected by the loading.

If anything, this latter method probably erred on the light side. The method used in the bolted joints on the other hand, recorded not only the actual slip of the joint but also measured any elastic or inelastic strains produced by unequal stress distribution across the transverse section of the inner and outer plates. Hence, these readings tend to exaggerate the true amount of slip.

Note that no slip whatsoever was observed in the riveted joints, represented by the dashed line graph, until the average shear on the nominal area of the rivets was approximately 18 ksi. From there on the slip was at a nearly uniform rate up to about .007 inches, at which point the rivets were probably in full bearing against the side of the holes. At approximately 37.5 ksi some of the rivets had sheared and the test had to be discontinued.

Returning now to the solid line, representing the slip of the bolted joints, note that there appears to be a very slight movement, almost from the commencement of loading. Undoubtedly this movement represents elastic strains in the connected parts, rather than any actual slip. The first major slip occurred at an average unit shear on the nominal area of the bolts equivalent to something more than 20 ksi, representing a factor of safety of approximately 1 1/3 over the AISC recommended unit working stress in shear or a factor of safety of about 1 1/2 with respect to the unit shearing stress recommended in the standard bridge specifications. The test data used in this comparison is somewhat more conservative than might have been used. The holes in the bolted specimens were sub-punched and reamed and, in the punching process, the plates were dished slightly, so that the plates did not lie in perfect contact with one another. The bolts were torqued to a tension equal approximately to their elastic proof load. All contact surfaces had their original mill scale.

In studying the test data as it is presented here, one must not lose sight of the very exaggerated abscissa scale which tends to leave the impression of an enormous amount of slip. The 1/16 inch clearance of the bolts in the holes is equivalent to a potential slip of .067″. Note that this amount of slip was not reached until the average shear on the nominal area of the bolts had reached an intensity of 30 ksi. At 37.5 ksi, the stress at which some of the rivets in the earlier series of tests had begun to fail, the loading of the bolted joints was discontinued, in order to salvage the bolts for re-use. At this equivalent unit shearing stress, the bolts seemed to have suffered no damage whatsoever.

From the test data here presented, it may be concluded that:

1. No appreciable slip is likely to be encountered in joints

where the high strength bolts are torqued nearly to their proof load, unless the applied loading on the joint is at least a third greater than that contemplated by the design.

2. In order to experience enough slip so that the bolts and plates will come into bearing, the applied load must be at least twice that intended by the design.

While much can be learned from laboratory tests, the proof of the pudding, for most people, is in the eating. The behavior of high strength bolted joints, under actual, severe service conditions in the field, has provided that proof. Upon the recommendation of AREA Committee 15, the research staff of the Association of American Railroads, about three years ago, embarked upon a program under which thousands of high strength bolts have been, or are being, installed in joints where the actual service conditions are known to be particularly severe. In the earliest installations these bolts were substituted for existing rivets in ore-unloading bridges, at points where, as part of the annual maintenance program, a certain number of loose rivets had to be backed out and redriven every year.

A case in point was one of the trolley stringer connections in the Pennsylvania Dock Company's ore bridge at Ashtabula, Ohio. Weather conditions were very unfavorable when these bolts were first installed using an ordinary open-end wrench. About two months later the bolts were carefully checked and adjusted with a torque wrench. The ¾″ bracing connection bolts appeared at that time to have retained all of their original tension. Some loss of clamping force was indicated in the 7/8″ trolley connection bolts, although this may have been due to imperfect torqueing in the first place. More likely it was due to failure to follow around the connection a second time, to pick up any loss of tightness resulting from subsequent torqueing of adjacent bolts in the same joint. Whatever the cause, eighteen months later, after the bridge had been used for two full ore-unloading seasons, a second inspection failed to reveal any further loss of clamping force in the bolts. These connections have now undergone three full seasons of operation without requiring any maintenance and are about to enter their fourth season.

High strength bolts which were substituted for loose rivets in an ore-unloader at first had common washers under their heads and nuts. At that time, hardened washers were not available. Two months later, using a torque wrench, it was found that the 18-7/8″ bolts, used to hold the 175# rail down to the main girder, were still tight. The 22-7/8" bolts used in the bracing connections at Joints 1 and 2 however, had worked loose several times under operation of the unloader, and had been retightened by the maintenance forces. Hardened steel washers were substituted for the common washers and all bolts were torqued to 470 pounds-feet.

These bolts were inspected again at the close of the navigation season eight months later. All but four were found to have retained their full clamping force. A year later they were again inspected and still were found to be tight. In the meantime, rivets, in the bolted 8 in. channel at the joint opposite Joint 2, had worked loose.

The 64-7/8" bolts, used to connect four diaphragms in the AT&SF bridge at Wilbern, Illinois, have lost none of their original clamping force after some two years of service. In this case the bridge was new when the bolts were installed. Hence the holes had not been damaged in backing out old rivets.

Because the rivets in the transverse bracing of the Chicago and Northwestern Railway bridge at Beaver, Iowa, had frequently worked loose, they had been replaced with ordinary standard bolts and spring washers. Within a year, however, these bolts had all worked loose, although not so loose but what the spring washers prevented the nuts from backing off the bolts.

High strength bolts have now been substituted. To date, some two years later, no evidence of loss in clamping force has been observed.

It is interesting to note that the clamping force recommended in using high strength bolts is approximately three times that which would be required to completely compress ordinary spring washers. Is it any wonder then that, in no case to date, either in the laboratory or in these closely-watched field installations, has one single nut shown the slightest tendency to back-off, even though no particular measures are taken to prevent this—such as the use of lock-nuts, spring washers or burred threads? Yet some joints have been loaded in the testing machines with as many as 8,000,000 cycles of loading.

I could describe several other field installations on dynamically loaded structures (at the present time some 14 are under close observation) but the results obtained to date are very similar to those already reported.

Aside from the superior behavior of these joints, the relative cost of their installation in the field, as compared with the cost of driving field rivets, is an aspect which has excited considerable interest in this new technique. While the cost of the bolts themselves is of course considerably more than the cost of corresponding plain, un-driven rivets, savings in the cost of installation often more than make up the difference. This is particularly true where a relatively few rivets or bolts, perhaps widely scattered around a given structure, must be installed at some remote site and the cost to bring all of the equipment required for driving rivets, would mount up fast.

Even under conditions more favorable for the driving of field rivets, the high strength bolt technique appears to be competitive or nearly competitive, from a cost angle alone, judging by the number of ordinary tier structures built, or now building, using high strength bolts for the field connections.

One of the first such buildings to be completed was a 14-story, 80′ × 100′ hospital for the University of Illinois in Chicago, designed by Holabird & Root. In this case it was reported that the use of high strength bolts for the field connections increased the cost of the work some $6.00 or $7.00 per ton. The bolts themselves constituted a special order, and were said to have cost 37 cents apiece as compared with perhaps 7 cents apiece for equivalent rivets. They were late in arriving at the building site and, rather than delay the progress of the work, standard erection bolts were used. These bolts had later to be replaced by the high strength bolts so that no net saving was effected in the erection cost, as might have been the case if the special bolts had been available when the erection was started.

High strength bolts were used this past year in lieu of field rivets, on the framing for an office building in Keene, New Hampshire, designed by Mr. W. H. Owens for Cram and Ferguson of this city.

At the present time eleven stories of framing for the proposed twenty-one story building at the Mayo Clinic, designed by Ellerbe & Company, are being erected, using high strength field bolts. Constructed adjacent to an existing hospital building, field riveting was tabued in the interest of noise reduction. After comparative cost study, the contractor elected to use bolts instead of field welding.

Under contract at this time, and scheduled for erection this summer, is the twenty-one story Mayo Memorial Medical Center at the University of Minnesota, designed by C. H. Johnston, Architect. In this case the field connections will be 1 1/8 inch high strength bolts.

Now under erection at La Crosse, Wisconsin, is an eight-story apartment house designed by F. J. Hinton, Architect. In this case the contractor had the option of field riveting or bolting and, after some study, chose high strength bolts.

As compared with an estimated increase in cost of $2.50 per ton of erected structural steel, due to the cost of the special bolts, a saving in erection cost of $6.00 a ton was estimated, showing a net saving of 11% for the erection. This estimated saving was based on the following factors:

1. Elimination of temporary erection bolts.
2. Elimination of transportation of riveting equipment.
3. Two-man crews to bolt up after erection.
4. Normal production of a two-man crew, four hundred bolts per day.

The bolts are being installed using air impact wrenches and are being spot-checked with a torque wrench.

Even when impact wrenches are used, the noise factor is considerably reduced over that for riveting and, of course the hand torqueing of the bolts is quite noiseless. Hence it is perhaps not without significance that three of the five tier buildings just mentioned are hospitals. Nevertheless, based upon comparative cost alone, the information developed to date would seem to indicate that the use of high strength bolts, in ordinary holes, requiring no special reaming and fitting, is quite competitive with other techniques, even on tier buildings.

What, then, are the salient points covered in the recommended specification recently adopted by the Council?

First and foremost is the fact that these bolts may be substituted unit-for-unit and at the same allowable shear stress, for structural steel rivets (ASTM, A141) of the same nominal diameter, to resist the shear at faying surfaces of any structural steel joint, and that, when such bolts are used, the required holes may have the customary 1/16 in. clearance associated with ordinary riveted work and with unfinished bolts.

Such bolts must meet the requirements of ASTM Tentative Specification for Quenched and Tempered Steel Bolts, serial designation A325. That is to say, they shall have a minimum yield point strength ranging from 74 to 90 ksi, and a tensile strength ranging from 105 to 125 ksi, depending upon the bolt diameter. They must conform to the American Standards Association's standards for Regular Semi-finished, Hexagonal, Head Bolts, ASA B 18.2 as to the threading and other dimensions, except that the radius of the fillet under the bolt head shall be at least 1/32 in. for bolts larger than 5/8 in. diameter and at least 3/64 in. for bolts larger than 1 in. diameter.

At least one carburized, or quenched and tempered, washer shall be installed under each nut and bolt head.

All nuts shall be tightened to produce a bolt tension of not less than 90% of the elastic proof load of the bolt.

A certain proportion of the bolts shall be checked for tension by a procedure of loosening and re-tightening, under controlled conditions. The exact number of bolts to be so checked is to be determined in advance by the engineer but, for the present, between 5 and 10% is the recommended proportion.

Several methods have been employed for torqueing these bolts to the tension called for in the specification. At the present time there appear to be two schools of thought. According to one school, equipment and techniques should be developed that would record or control the amount of torque applied to every bolt; according to the other school, calibrated devices would be made available at the building site, so that each iron-worker could practice until he had acquired a "feel" for the desired torque.

For the present at least, the specifications just adopted would require a spot check of the work done under either approach to the problem. The months immediately ahead should prove interesting since, with the new work now pending, there should be ample opportunity to see which is the more practical approach to this problem intimately involving the human equation.

In closing I should like to quote one short paragraph from a report which Professor Wilbur M. Wilson read before the Highway Research Board in Washington earlier this year. Professor Wilson was talking to state bridge engineers. Hence his reference to structural engineers and their earlier position with respect to bolted joints reflects the attitude of bridge engineers rather than all structural engineers. He said:

"Until recently, structural engineers did not consider bolted joints to be suitable for fabricating permanent steel structures. Today, the structural engineers of some railroads are using high-strength bolts to replace rivets in the fabricated joints of their bridges for which the rivets had either failed or loosened in service. The writer knows of no other instance in which the status of an engineering process has changed so completely and in so short a time, from one in which the process was considered unsuitable to one in which it was considered to be superior to the process which it replaced."

WINDSTORMS AND THEIR AFFECT ON BUILDINGS

By J. A. Wilson

(Presented at a meeting of the Structural Section of the Boston Society of Civil Engineers, held on February 14, 1951.)

The Midwest and parts of the South with their tornados—Florida and Gulf States with their hurricanes—have popularly been supposed to be the only sections of the country subject to really destructive windstorms. Actual experience shows, however, that any structure in the United States or Canada is subject to and many have suffered serious wind damage.

The purpose of this discussion is to emphasize that certain design and maintenance deficiencies exist in industrial buildings, a fact proven by actual experience, and that these buildings should be designed for not only normal downward loads, but also for other loads caused by the wind. The paper will include a description of the type, characteristics, etc., of windstorms, the resulting forces acting on industrial type buildings, experience data showing where the losses occur, and preventative measures which can be taken.

Windstorms can be divided into three basic categories: (1) Gales, squalls, thunder and hail storms; (2) tornados and (3) hurricanes. We are all familiar with category 1. Generally speaking, they are of short duration and are confined to relatively small areas of the country. They are characterized by a small and slow drop in barometric pressure, accompanied by gusty winds and generally with rain. These storms occur in all sections of the country.

A tornado is characterized by a rotating cone-like vortex with wind velocities of probably 200 to 300 mph. which causes almost total destruction in a relatively narrow path varying from 200-1500 ft. in width. Outside the narrow path of the vortex the velocity of the winds feeding the vortex may be mild to severe. The vortex follows an irregular path and also has "up and down" or "jumping" action. Barometric pressure within the vortex of a tornado is very low. Buildings within the vortex sometimes explode due to the difference between internal and external pressures, the forward motion of the vortex being such that equalization of pressures cannot take place in time to prevent damage. Weather Bureau records show that tornados occur with greatest frequency in the Midwest and Southern states, but also that over a 35 year period they have occurred in 47 of the 48 states.

Hurricanes have wind velocities ranging from 75-125 mph., widths varying from 75 to 300 miles and are accompanied by a slow drop in barometric pressure. They originate in the Caribbean or West Indies area and travel in a northerly direction along either the Gulf or Atlantic Coast. Their exact path is dependent upon the atmospheric pressure conditions prevalent at the time of the storm. A hurricane has considerable width and has velocity due to both translation and rotation.

These velocities act together on the easterly side of the storm and in opposition on the other side so that the most severe wind condition occurs on the easterly side of the hurricane. Areas 7-15 miles in diameter of complete calm and often with sunshine, have frequently been observed at the center or "eye" of the storm. The destructive force of a hurricane is greatest along the coastline, when it travels inland its energy is rapidly dissipated, generally within 50-150 miles of the coastline.

Knowing these three general types of windstorms, the next question is—what forces do they create on a building? Wind tunnel tests have been conducted by many agencies and individuals on variously shaped models. These tests have disclosed there are two basic wind forces acting on a building, an exterior suction force on the roof and leeward walls and an internal pressure within the building. These forces have been evaluated by most researchers in terms of a factor which is applied to the velocity pressure produced by the wind. The velocity pressure is the force produced by a given wind on a flat surface perpendicular to the wind direction and is expressed in pounds per square foot.

Although the suction force depends on the size, height and shape of the building, the most important variables are the direction of the wind and the slope of the roof. With the wind blowing perpendicular to a side wall, uplift or suction is greatest with a flat roof. As the slope of the roof increases, the suction decreases on the windward slope until at about a 30 degree slope, there is little or no uplift. On steeper slopes the wind exerts a downward pressure on the windward slope. There is a suction force on the leeward slope of all pitched roofs.

The internal pressure within a building is caused by wind entering the building through windward openings, building up a positive pressure inside which acts upward on the underside of the roof and outward on the walls. If a building remains tightly closed, or the windows are open on all sides during a windstorm, it will, of course, not be subjected to such internal pressure. Experience shows, however, that windward windows or doors are generally broken in most serious storms and it would be unwise to neglect the effects of internal pressure.

The term "Factory Mutual System" will be used several times in the paper and should properly be defined at this time. The system consists of nine Associated Factory Mutual Fire Insurance Companies providing comprehensive fire insurance for primarily industrial properties throughout the United States and Canada. These Companies presently have a total of 35 billion dollars at risk at approximately 25,000 locations, including many of the large industrial facilities in the country. These nine companies also support, as part of the System, the Factory Mutual Engineering Division and Laboratories which provide inspection, engineering, research, appraisal, and adjustment services as required by the member companies.

In formulating the standards for the Factory Mutual roof anchorage program, we have reviewed all available test data on the wind forces acting on buildings. Although we have utilized values of several individual agencies, their data have in each case, been substantiated by tests performed by other agencies.

For the suction force on main building roofs with slopes of 20° or less, we have used a value of 0.77 times the velocity pressure. This value was based on Research Paper No. 301 of the U. S. Bureau of Standards, which reported the results of wind tunnel tests on a model mill building with a 20° roof slope. Where necessary, with buildings having roof slopes in excess of 20°, we utilize values for suction or pressure on the roof exterior as recommended by the A.S.C.E. Sub-Committee No. 31 on Wind Bracing in Steel Buildings.

For the internal pressure, we have used a value of 0.73 times the velocity pressure. This value is based on a paper prepared at the University of Melbourne, Australia, which reported results on wind tunnel tests on a mill building. In these tests, it was shown that internal pressure was developed when only 10% of the windward face of the building was open to the wind.

The wind velocity to be used was determined by a survey of U. S.

Weather Bureau data from various stations throughout the country. It was arbitrarily decided after considerable study to use a 67 mph. 5-minute average wind velocity representing an 87 mph. gust velocity. Although this velocity did not represent the most severe condition, it was considered that it was representative of most storms and the frequency of the more severe storms was such that the factor of safety of any roof anchorage design could be depended upon to prevent damage under such extreme conditions.

To convert the 67 mph. wind velocity to an equivalent velocity pressure, refer to the Wind Velocity Conversion Chart, Fig. 1 in the attached F. M. Bulletin 7.10. You will note by following the heavy dash line that the velocity is corrected for gusts and, when corrected, is equivalent to a 20 lb. per sq. ft. velocity pressure. The correction for gusts is necessary because most Weather Bureau wind velocity data are 5-minute averages. If a weather station reports gust velocities, no correction is necessary. The chart was prepared from data

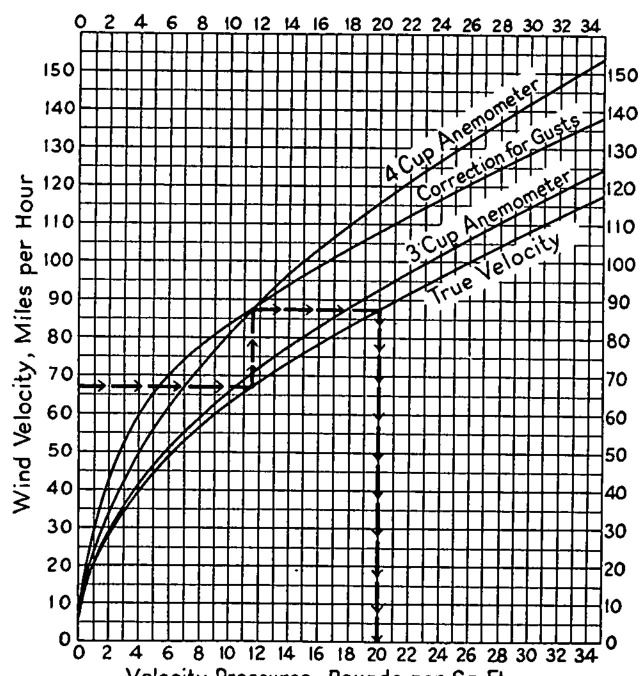


FIG. 1.—WIND VELOCITY CONVERSION CHART.

submitted by the U. S. Weather Bureau. In connection with the use of this chart, it should be noted that the Weather Bureau currently records true 1-minute, 5-minute and/or gust velocities and that 3 or 4-cup anemometer readings are no longer recorded directly.

Having information on the suction force, the internal pressure, and the wind velocity, the gross wind uplift force on a flat roofed building can now be computed to a term readily understandable to the layman. The gross force on the roof is equal to the sum of the exterior suction and interior pressure forces as follows:

$$0.77\ V_p + 0.73\ V_p = 1.5\ V_p$$

The velocity pressure for a 67 mph. wind (5 min. ave.) is equal to 20 lb./sq. ft., substituting in the above formula, the gross wind uplift is equal to 1.5 times 20, or 30 lb./sq. ft. This is the most commonly used value in our factory roof anchorage program. Uplift values for roofs with slopes of over 20°, and for monitors, sawteeth, etc., are derived in a similar manner, the only variable being the external force factor which varies with building shape or roof slope. Proper force factors and sample computations for these cases may be found in the attached F. M. Bulletins 7.10 and 7.13. Bulletin 7.10 also presents a more detailed discussion of the wind forces acting on industrial type buildings.

Having discussed the types of windstorms and the forces they cause on buildings, let us see why we are interested in these subjects.

We have recently completed a survey of the windstorm losses within the Factory Mutual system over a 15-year period from 1935 to 1949 inclusive. This survey indicates the windstorm loss has averaged approximately $1,000,000 per year. A summary of these losses by type of storm is shown in Table I. This tabulation emphasizes the number of losses which are caused by the supposedly less harmful lower velocity winds. Although the total amount of loss from these

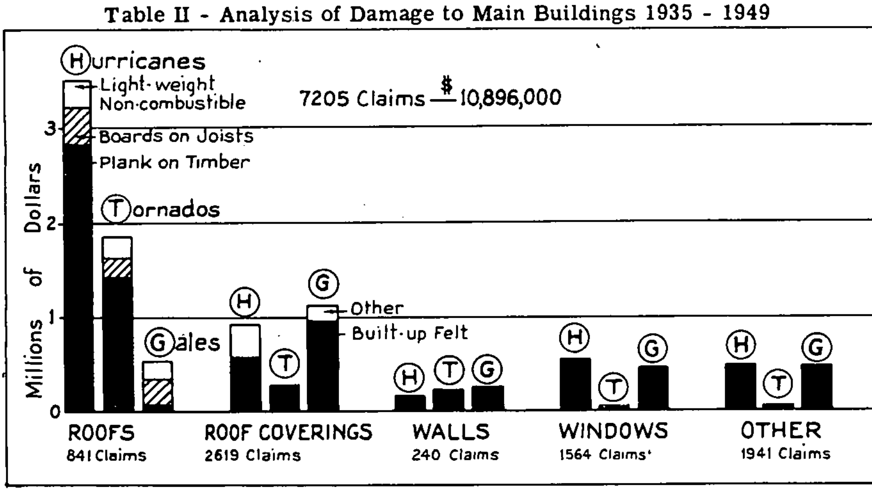
Table 1 - Summary of Losses by Type of Storm 1935 - 1949

	Number	Property Damage	U. and O.
New England Hurricane (9-21-1938)	977	$ 5,000,000	$ 630,000
Other Hurricanes	660	1,306,000	222,000
Gales, Squalls, Hail	6834	3,543,000	228,000
Tornados	183	2,657,000	506,000
Totals	8654	$12,506,000	$1,586,000

winds is less than from the higher velocity hurricanes and tornados, they still account for 27% of the total losses.

Damage to main factory buildings and their contents made up 83% of the claims and 87% of the property damage listed in the above noted table. The remainder of the damage was to outside property such as cranes, stacks, sheds and village property. Table II breaks down the damage to main buildings by type of storm and type of damage.

Table II - Analysis of Damage to Main Buildings 1935 - 1949



Damage to roof decks including resultant damage to contents, has made up more than half of all damage to buildings. Hurricanes have caused more roof damage than tornados and gales combined. Roof anchorage would prevent practically all roof damage from hurricanes and gales and it would also prevent some of the tornado damage outside the path of the rotating vortex. Gale damage to plank roofs is low because such a roof can generally withstand the lower uplift forces from the gale winds. In the survey, no case of damage to a reinforced concrete roof by a tornado, hurricane or gale was reported in the 15-year period.

Damage to roof coverings is the most frequent type of damage and is caused by all types of storms. Most of the damage has been to built-up felt roofing which is by far the most prevalent type in our insured properties.

There are two basic types of built-up felt roof coverings, those with a smooth surface and those with a gravel or slag surface. It is estimated the amount of each type within the Factory Mutual System is approximately equal. The gravel surface type is more resistant to wind and hail damage probably because of its added weight and greater durability. Table III summarizes our loss experience with the two

Table III - Analysis of Damage to Built-up Roof Coverings 1935 - 1946 (excluding hurricanes & tornados)

	Number Of Losses	Average Loss
Wind Damage		
Smooth surfaced	614	$ 720
Tar and gravel surfaced	174	$ 369
Hail Damage		
Smooth surfaced	149	$1,280
Tar and gravel surfaced	4	$ 406

types of built-up felt roof coverings and shows the definite superiority of the gravel surface type. Inadequate nailing or mopping of the bottom plies and poor bonding between the roofing felts appear to be the primary reasons for failure.

Damage to walls has been mostly due to lifting of unanchored roofs by hurricanes and tornados with resulting collapse of the walls due to lack of lateral support at roof level. In addition, a number of inadequately braced masonry walls of buildings under construction have been blown over by gales and squalls.

Damage to windows is generally the result of poor maintenance although we have had several losses due to improper settings. Windows are frequently damaged by ordinary storms as well as by hurricanes. Rotted wood sash and corroded metal frame windows have proved particularly vulnerable.

Other damage to main buildings was mostly to monitors, ventilators, copings, cornices and gutters.

Damage to outside property other than main buildings amounted to 13% of the total loss. These losses are shown in Table IV, by type

Table IV - Damage to Outside Property 1935 - 1949

Plant Property	Number of Claims	Amount Of Loss
Cranes	21	$ 325,000
Sheds and Small Buildings	223	267,000
Masonry Chimneys	87	209,000
Steel Stacks	330	180,000
Tanks and Towers	200	82,000
Power Lines	100	70,000
Trestles	29	50,000
Yard Storage	32	20,000
Miscellaneous	275	191,000
Total (Plant)	1297	$1,394,000
Village Property	151	$ 216,000

of structure damaged. Although this data has no direct connection with this discussion, it has been included as a matter of interest and to complete our 15-year summary of wind storm losses.

The above loss summary does not include the November 25, 1950, windstorm which caused extensive damage throughout the northeastern section of the country. This storm had 5-min. ave. velocities of up to 70 mph. and gust velocities up to 100 mph. and was classified as a gale by the Weather Bureau. In this storm, the Factory Mutual System received 1600 claims with an estimated total loss of $4,000,000. Until final adjustments are completed we will not have a detailed analysis of the loss. There are, however, several general statements which can be made at this time.

There were only twenty-five claims which amounted to $25,000 or more. Wind uplift damage to roof decks was involved in only eight claims, but the amount of loss for these eight claims was over $500,000. Most of the other claims were relatively small in value, involving damage to roof coverings, windows, monitors, ventilators, cornices, signs and gutters. We expect the detailed analysis on the loss data will closely approximate the proportions of the gale sections of our 15-year summary shown in Table II.

Factors which contributed to the overall loss from this storm were the extent of the storm, the water damage resulting from the heavy rains which accompanied the storm and its occurrence on a weekend. It is probable roof anchorage would have prevented most of the roof deck damage and proper or possibly better plant maintenance would certainly have reduced the other losses. An immediate start on salvage and repair work would have further reduced the amount of damage as many organizations did not start salvage operations until the Monday following the Saturday storm.

The windstorm loss data definitely shows the primary structural deficiencies of the average factory building. We must now consider what can be done to eliminate these deficiencies before or during the construction of the building.

First, considering new buildings, we recommend they be designed to resist a gross wind uplift of 30 lb./sq. ft. If accomplished at the time of construction, this work can be performed easily and economically. To date, we have had no damage to building roofs which have been properly anchored. This statement has been substantiated by actual cases where nearby unanchored roofs of equal or greater dead weight have lifted during various wind storms.

New roof covering should have a gravel or slag surface and should be furnished with at least a 15-year bond or guarantee. Each intermediate ply of the covering including insulation should be firmly embedded in a complete mopping of hot pitch or asphalt, to obtain good bond. During the roofing operation, extreme care is necessary, especially during cold weather that succeeding layers of felt or insulation are embedded in the pitch or asphalt before it has had a chance to cool and set. Where possible, the two bottom plies should be nailed to the deck with one 1-inch nail for each square foot of surface, each nail having a 1-inch diameter tin washer under the head. Where nailing is not possible, the bottom ply should be bonded to the deck with a complete mopping of pitch or asphalt.

For existing buildings, we recommend the roof framing be anchored, if anchorage is practical and if the possible resulting damage to a building and contents is likely to exceed $25,000. If the contents of an existing building are not susceptible to water damage, structural damage to the building alone is seldom sufficient to justify roof anchorage.

Little can be done to increase the windstorm resistance of existing roof coverings. We recommend continuing careful maintenance of the coverings, flashings and edgings and our inspectors have instructions to watch for such deficiencies.

Building walls are generally designed to resist normal wind loads when supported at the top and bottom. If the roofs are anchored so that the top of the walls are not deprived of their support by lifting of the roof, it is extremely unlikely the walls will be damaged by the wind. For walls under construction, we recommend the use of temporary bracing whenever the unsupported height of the wall exceeds ten times its thickness.

The other deficiencies of main buildings as indicated by the windstorm loss data (windows, monitors, ventilators, copings, cornices and gutters) are primarily due to lack of maintenance, over which the designers have little control. For these items, the designer's primary responsibility is to provide a structure which initially will be able to resist expected wind loads and resist the affects of the weather with proper maintenance.

Members of the Boston Society of Civil Engineers have and will play an important part in the design of new industrial facilities and in the remodelling of existing facilities. In that role, their designs should properly include consideration of all the forces which act on a structure. It is hoped this paper has shown that wind uplift forces have a part in any building design and that such forces will be included in any future work in which you participate.

ARCHITECTURAL CONCRETE

By E. B. Oberly

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Structural Section B.S.C.E., held on February 16, 1949.)

Concrete is one of a number of materials which can and is being used as a facing for all types of structures throughout the country, and is not limited to certain localities as is often thought by many architects, engineers and contractors. The reason for the belief that it can be used only in certain areas is always "climatic conditions". This mistaken idea has been thoroughly investigated and proven to have no foundation. As a matter of fact, more structures of this type performing excellently can be seen in and around the state of Minnesota than in the state of Florida.

Concrete in the New England States has been looked upon, as in many other parts of the country, as a structural material only. As a result, too little attention has been given, or effort made, to construct good forms.

It has been quite a task to make the average contractor, and especially his superintendent, understand that on architectural work more care must be taken in the building of forms and in placing the concrete. It has been difficult to make them realize that they are working with a finished product and not one that is to be covered by another facing material or otherwise hidden from view.

Construction of good formwork is one of the most important steps in securing good appearance in an architectural concrete structure and should be considered from a different viewpoint than an ordinary structural concrete job. Among the primary considerations are a uniform texture and a fairly uniform color. Poorly built formwork can prevent a good appearance regardless of the quality of the concrete, or the care used in the placing and other operations in the production of the concrete.

In the past it has been the practice of architects and engineers to specify the quality of concrete in terms of strength only. This was proper enough when concrete was used as a structural material only, but since little if anything was specified as to appearance, the contractor would choose those procedures which, in his opinion, were the most economical. This practice must be modified in planning a job where the concrete is the architectural medium.

The form material and the methods used to execute the job will govern the final appearance, hence the architect is entirely within his rights in requiring the contractor to conform to a few basic principles which have proven so necessary in order to obtain the desired results. These principles may be violated occasionally with little apparent damage, but unsatisfactory results will occur so often that inspectors should have some means of preventing the inexperienced contractor from neglecting them. This will work no hardship on the competent contractor, as he will know that the cost of preventing trouble is far less expensive than the cost involved in fixing it after it has occurred.

The methods used by the competent contractor, most familiar with this class of work, have been fairly well standardized and are a practical balance between costs and results.

The specifications should cover all phases vital to exposed concrete, as the type of form material to be used in order to produce the texture, the type of form ties to be used, the gradation of aggregates, the water-cement ratio and slump of the concrete and other items vital to good concrete. The plans should also include details of construction and particularly control and expansion joints. These can be typical details for the job.

In detailing forms care must be taken that, when assembled, the pressure of the concrete will tighten all joints rather than loosen them. The forms should be designed so they can be stripped easily, not only to aid in their removal, but to obtain as many re-uses of the materials as possible.

A common source of trouble is the bulging of forms at external corners. This results in both poor alignment and leakage which must be prevented if a straight, sharp corner is to be produced. This point probably sounds rather elementary to most of you, but it is surprising the number of jobs on which the requirements for good results at this location are neglected. By extending the wales beyond the intersecting point a distance far enough to permit the two vertical strips to be nailed in the corners with double-headed nails as shown in this slide, no opening of the external corner can occur unless the lumber shrinks too much before the concrete is placed. In the latter case it will be found necessary to wedge between these strips and the wales in order to tighten the corner. All of this wedging should be done before starting to place concrete, as leaky forms cannot be properly taken care of while placing is in progress.

In a considerable proportion of our present-day work, smooth forms are required. A very high percentage of these jobs can be handled best by the use of structural plywood. Plywood made especially for concrete forms should be purchased and thoroughly oiled at the factory or on the job before using. The oil should be allowed to penetrate thoroughly and then any surplus oil should be wiped off before setting. Plywood either ⅝ or ¾ in. in thickness can be used directly against the studs and requires no backing. Care must be taken that outer plies are at right angles to the studding. On a number of jobs the contractor has persisted in running the outer ply parallel to the studding. With about an average placing speed, the deflection will not be very noticeable on the first use. With the second use of the plywood the deflection will be quite noticeable, but with the third use I have observed deflections up to ¼" where the studs have been placed 16" on centers. This practice should not be permitted as there is nothing to be gained in cost and since we know that a serious deflection will take place. Quite often this is done on jobs where plywood is used and the height of the placing fits the size of the plywood sheet. We find it necessary that all joints, both horizontal and vertical, must be backed up solid and both sheets of plywood fastened to the backing to prevent any deflection or movement between the sheets of plywood. Occasionally one sheet may be slightly thinner and in this case thin wedges should be used to bring the adjacent sheets into line. This will be necessary to eliminate the joint to the fullest extent. In using structural plywood we make no attempt to plane or dress the edges of the individual sheets where they abut on a flat area. If both sheets are fastened into the same backing, the joint can be easily filled with a prepared material available in all sections, or a mixture of tallow and cement can be used.

We have found that the most successful practice in cleaning and oiling plywood after it has been used the first time is to pull all nails and clean the plywood immediately after it is removed from the concrete. There will be a little dust sticking to the surface of the plywood. This can be removed with a common broom. After sweeping off this dust, sanding with No. 1½ sandpaper will clean and at the same time remove any raised grain. When plywood is cleaned in this manner the fourth or fifth use will probably give a better result than even the first. This method is also as inexpensive as any that we know of. The use of steel bristle brushes to clean plywood should not be permitted as the soft grain will be grooved out enough to show in the concrete surface.

Figure 1 illustrates two ways of detailing, one of which results in lower cost than the other and at the same time less trouble in breakage of corners while stripping. In the upper detail you will note the large heavy members milled from a single wide board. The heavy

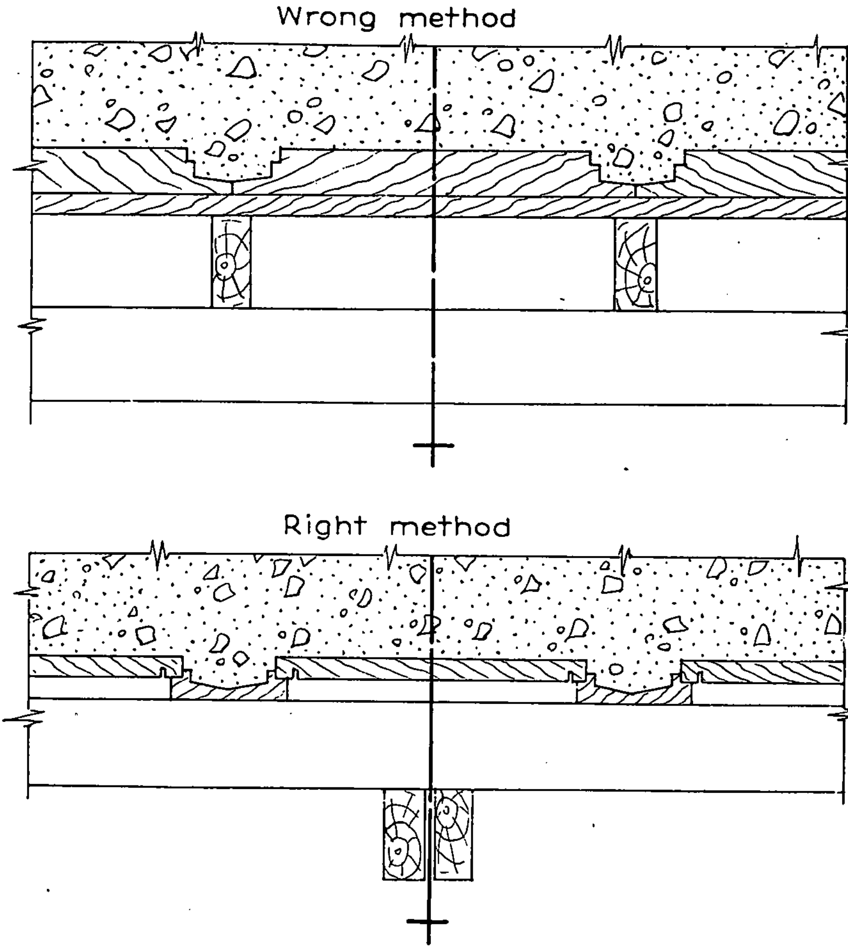


Fig. 1.—Right and Wrong Method of Detailing.

member will probably swell and fracture the corners in the projecting concrete.

In the lower section it is evident that less lumber would be required, also the size of the various pieces would be smaller and the milled piece for the projecting member is detailed and milled in a manner that any swelling would be away from the concrete.

For belt courses, cornices or other ornamentation where continuous members occur, wood moldings run to the proper shape may be used.

Figure 2 illustrates a typical example. Some contractors may prefer to use a waste mold for this detail. If wood molds are used care should be taken to select a soft-grained wood that will not warp or split easily. A soft white pine is the best possible material, but if it is not available a soft-grained Douglas fir may be used. You will note that the various members are narrow enough that the common

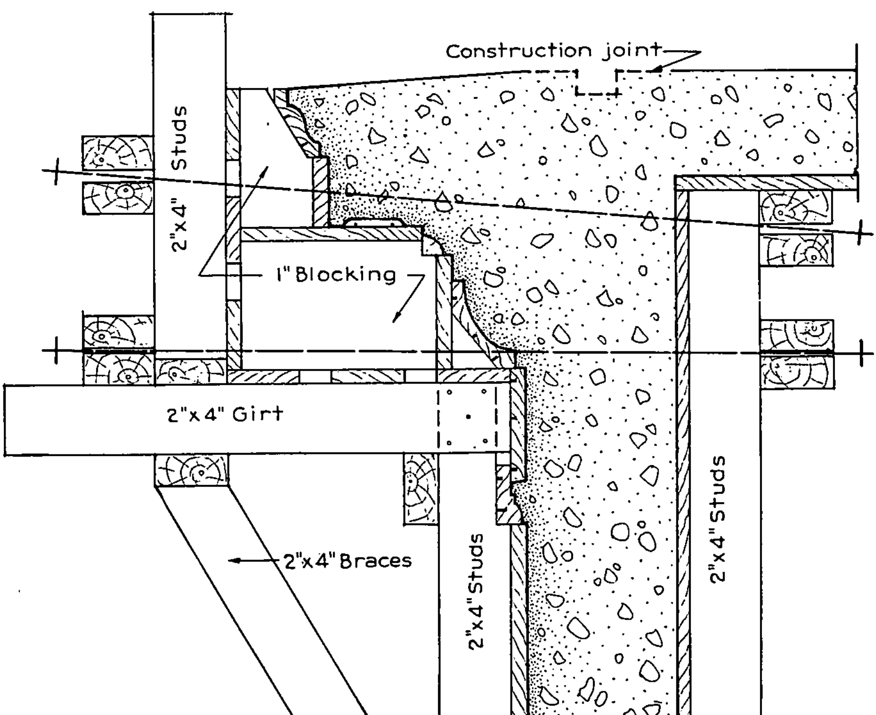


FIG. 2.—WOOD MOLDINGS FOR FORMS.

stock sizes of lumber could be used in all cases. Also note the generous use of saw kerfs in the back side to prevent swelling and warping.

One of the great advantages in the use of wood molds in ornaments of this type is that the various members could be broken at different points which would make it much easier to hold proper alignment than if the entire form were cut at one point as would be necessary in a waste mold. In molds of this type all members should be thoroughly oiled on all sides before forms are built.

Wherever possible on architectural concrete jobs the face forms should be erected first. If this is done it is very easy to be certain that forms are tight at all construction joints and any fitting or touching up at the joints can be done before there is any obstruction. It will be necessary at all construction joints to have clean-out pockets through which sawdust, chips or shavings can be removed just prior to placing concrete. Also, it may be necessary to have inspection pockets at various places and holes through which the concrete can be placed at some of the difficult points. These details should be discussed with the concrete foreman in advance.

Boxes, waste molds, wood molds, rustication strips or anything applied to the face of the forms should be nailed as lightly as possible in order that such parts will pull loose from the forms when the forms are stripped so that the inserts will remain in the concrete. After the lumber forming these ornamental details has dried out and shrunk it can be removed easily without damaging the concrete.

In the past there has been considerable trouble with strips swelling, even though well oiled. When the strips were removed considerable breakage of concrete corners would result.

We find that a saw kerf approximately two-thirds the depth of the member will prevent this trouble. On wide strips it may be necessary to have two or more saw kerfs. Generally there should be one saw kerf within ¾″ of each edge and at intervals in between of not over ¾″.

The strips can be nailed with double-headed nails from the outside of the forms. These can be removed before the form ties are loosened. Finish nails driven from the inside may also be used. These nails must be long enough to extend through the detail and form material sufficiently so that they can be pulled from the outside before the form ties are loosened. This means that the head of the nail is to be pulled through the materials, but this can be done easily unless the insert is made of hard wood. In that case double-headed nails should be used.

When finish nails are used care must be taken not to nail into the studs, but between them.

Either one of these methods is a must if a first-class job is to be expected. Even though inserts are made to be removed easily by beveling one or both edges, a very slight movement of the forms when form ties are loosened or forms are removed will injure the edges of the concrete. This will require very careful patching as a concrete job is no better than the patches.

For highly ornamental work, the use of waste molds (Figure 3) may be found necessary. For the general procedure of work requiring the use of waste molds a short description of that construction might not be out of order.

After the artist has conceived his design of the ornamentation and his drawings are prepared, they are turned over to a molder who makes a positive model of clay or some other material. From this model the procedure is to cast a plaster negative and then a positive is cast with glue. From the glue mold as many waste molds as may be required can be cast. The final waste molds are made by taking

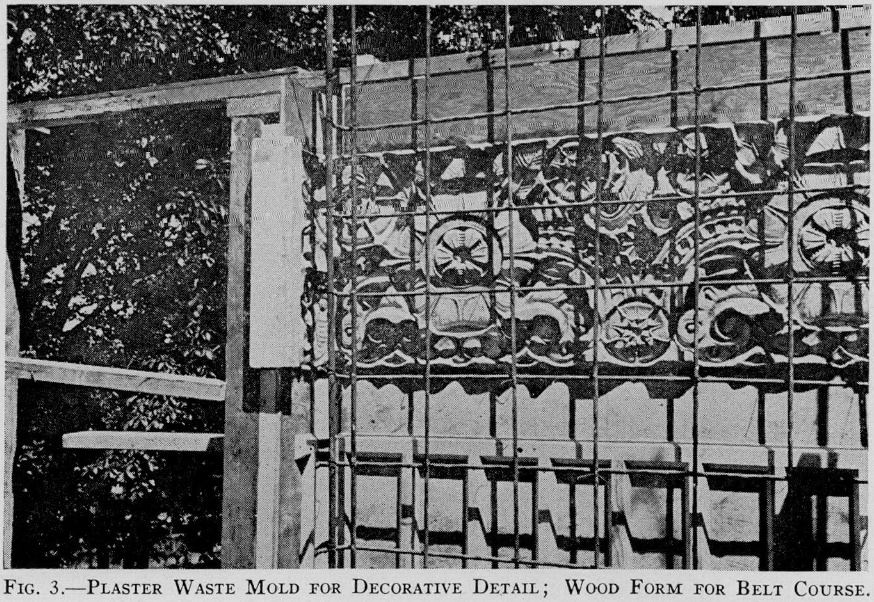


FIG. 3.—PLASTER WASTE MOLD FOR DECORATIVE DETAIL; WOOD FORM FOR BELT COURSE.

impressions from the glue mold, using gypsum casting plaster reinforced with hemp fiber or burlap.

Ordinarily waste molds are about 2" thick and are reinforced on the rear with 2 × 4 braces which are attached to the casting by means of burlap dipped in plaster. The braces in turn act as studs or wales when the mold sections are attached to the forms.

One of the most important items of an architectural or exposed concrete job is the shrinkage of the concrete while it is hardening and the expansion and contraction with climatic changes especially changes in temperature. This must be taken care of by the use of expansion or control joints. The one more commonly used is made by wood strips nailed to the form. These strips are milled out of soft wood, preferably white pine. The strips are placed at a distance of from 18' to 20' apart in walls where no openings occur. In walls where there are openings they should be not over 20' apart. When openings are not over 3' 6" in width the control strips are placed over and below the openings, in the center of the openings. Where openings are over 3' 6" wide, two strips are placed over and below the opening at the quarter point of the opening. In addition to these strips at least 50% of the temperature steel should be cut in order to weaken the wall at this point. Upon shrinkage a straight crack will form at the joint. The joint may be filled with calking compound if desired.

The subject of form ties is also quite important and always comes up for discussion when exposed concrete is being considered. The qualifications of form ties should be rated in order of their importance, as what would be considered important on one job might be a minor importance on another. Many of the patented ties have more or less merit. There are some ties which will work on any type of job while others will not. A study of the job should be made before a selection is made.

After the selection has been made a statement in the specifications should make it clear just what tie will be accepted on certain portions of the job, and what will not be accepted.

Important items to look for when selecting ties are: be sure that they can be removed from the wall to a distance of at least 1½" inside the face of the wall; that they have a minimum strength, when fully assembled, of at least 3,000 lb., that they are adjustable in length to permit tightening of the forms; that they leave a hole no larger than ¾" in diameter and at least ¾" in depth. The ties should not be fitted with cones or washers, as mortar patches in shallow or tapered holes will not stay in place.

In the past and even today, the most serious objection to the use of architectural concrete is sloppy and unsightly construction joints. To prevent unsatisfactory joints we find it necessary to provide ties whose sole purpose is to hold the form tight against the hardened concrete on the exposed side of the wall. This will prevent bulging or leakage at the construction joint which has caused so much of our trouble with this detail in the past. The bolt will work best if threaded on both ends. Certain types of patented ties have been used instead of bolts. If this is done the same tie assembly can be used at this joint as throughout the job if the ties are of certain types.

If a bolt is used for this purpose it is removed from the wall and reused and nothing but the nut is left in the concrete. For best results ⅝″ bolts should be used, spaced not over 2′ 6″ o-c, and placed 4″ below the top of the construction joint. On high buildings the bolts will also serve as scaffold bolts as well as carry the weight of the formwork and brace the forms.

A ¾″ strip must also be placed on the line of the construction joint in order to produce a straight line on the face of the wall. If rustication strips are used at these horizontal construction joints they will serve the same purpose.

When concrete has been placed to this level and has hardened the forms must be stripped and reformed for the next lift. The form lining should not lap down over the hardened concrete more than 1″ to get a tight joint.

This detail is essential if a good horizontal construction joint is expected and should always be shown on the detail drawings.

It can also be noted that if at any point the form lining does not fit tight, blocking and wedging at points between the studding will force the sheathing tight against the wall.

After the exterior forms have been placed and all inserts, as door and window bucks, control joints, rustication strips and other inserts are in place, reinforcing steel should be placed and not before. In exposed walls all steel should be placed at least 2″ away from the form lining. In order to be sure of this a 1″ × 2″ wood strip should be placed against the face of the wall in a vertical position, tacked only at the top of the form with a nail that can be removed easily when concreting is started. This will keep the steel at the proper distance from the form. The strips should be placed from 6′ to 10′ apart depending on the size of the steel. These strips can be pulled up gradually as the concrete comes up in the form.

A Z-shaped bar should be used where two curtains of steel are used. With this spreader and the strip against the face of the form, the two curtains will stay in place.

Extra steel must be used to reinforce the wall wherever there is a chase. If this is not done cracks may develop at the chase before the control joints start working, as the wall may be weaker here than at the control joint.

The care used in placing concrete is important in securing good results on any concrete job, and especially so on buildings where the exposed concrete is the architectural as well as the structural material.

The concrete must be spaded, puddled or vibrated into all corners, angles, ornamental or other difficult places in order to be certain that no rock pockets or voids are formed. On the other hand some care must be exercised that over-tamping or over-vibration, especially of the more plastic mixes, is not done as this may cause segregation and the excess water may be forced to the face of the form, causing sand streaking and discoloration as it rises to the surface.

The wetness or stiffness of the mix will depend on several things such as the method of placing, the size of the members and the amount of steel in the member as well as the ease of spading or vibrating in the most difficult places.

After all foreign matter has been removed and the forms have been washed out, cleanout holes can be closed. The hardened concrete should be damp but no pools of free water should be permitted after the forms are wet down.

Concrete should be placed in fairly uniform layers and for best results the layers should not exceed 18 to 24 inches at one time. The limits of the vertical speed will depend somewhat on the consistency and the quality of the mix being used, but in general should be held under 2 feet per hour. In no event should the concrete be placed at a speed that will cause free water to rise to the top.

To be certain that no honeycomb will be formed and to provide a better bond with hardened concrete as at a construction joint, placing must be started with grout about 2″ in depth, another procedure is to start with concrete reducing the coarse aggregate by 50% and cutting back the water so as to hold the same slump. This placing should be between 6 and 10" in depth. This serves a dual purpose, as it will provide the necessary surplus of mortar to prevent honeycombing and will give better bond at construction joints.

This grout or concrete should be placed only a short distance ahead of the regular concrete as it will stiffen rapidly, especially on a hot day, and the regular concrete will not be worked into it. There need be no different color or texture as the surplus mortal will be mixed with the regular concrete above.

In architectural concrete work suitable means must be provided for keeping the forms clean above the level where placing is in progress, and also for the prevention of segregation caused by the falling of the concrete. In some cases both of these can be accomplished by the same method. On jobs where the placings are shallow, a hopper can be used but on deeper placings, a canvas elephant trunk or a rectangular metal tremie about 3 by 8 in. in size will accomplish the desired results.

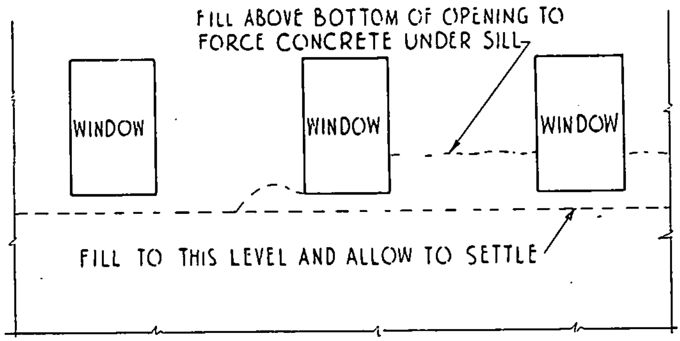
If a hopper of some type is not used, even on shallow placings, a splash board must be used. These are difficult to handle at best and give the wall less protection than a hopper.

A mix that is suitable for this class of work will not segregate under these placing conditions. The placing gang should bear in mind at all times that if the forms are splashed with concrete and the splash is permitted to dry, it will cause trouble. This splash will probably adhere to the concrete in some cases and in other cases it will adhere to the forms. Soon after the forms are stripped the splash will peel off or it may remain until the first winter when the frost action causes it to spall off. In either case the result is the same, a horrible disfigured job. These blemishes are often blamed on every thing except their real cause.

When a projection or a recess, such as a belt course or a water table, is reached in the placing of concrete the top layer of concrete should be held approximately 6 or 8" below the recess. This will permit the fresh concrete to settle and any surplus of water that might rise can be disposed of before proceeding with the placing.

In this manner the projection will be near the bottom of one layer of concrete and there will not be sufficient water gain for a layer of laitance to collect on the underside of the form, causing an unsightly appearance. This laitance, if permitted, will cause an unsightly appearance. Sometimes an attempt has been made to cure this trouble by rubbing. This will cure the trouble temporarily, but any condition permitting free water or laitance to collect at points similar to this will cause a lower quality of concrete and the snow and ice which collects in these areas will cause disintegration while the remainder of the wall may remain in good condition.

Figure 4 shows how concrete should be placed under windows or



CONCRETE SHOULD BE PLACED FROM ONE SIDE OF OPENINGS IN WALLS UNTIL IT FLOWS UNDER AND FILLS THE SPACE BELOW THE OPENING.

FIG. 4.—PLACING CONCRETE UNDER WINDOWS OR OTHER OPENINGS.

other openings. Place the concrete up to within 6 or 8″ of the sill or bottom of the opening and allow it to settle; before it has stiffened too much and while the next layer can still be worked into it without a flow line showing, start placing concrete again between any two of the windows or openings until the space underneath the sill is completely filled as shown by the dotted line on the slide.

It may be necessary on wide windows to provide access opening in the sill form through which concrete can be deposited, tamped or worked. After being certain that the space beneath the opening is completely filled as shown, placing can proceed between the next two windows. Under no condition should any attempt be made to flow the concrete under openings from both sides. If there is free mortar or water on the lift below, it will collect at the sill and present a very poor appearance, as well as produce a lower quality of concrete.

If a proper mix is used, concrete can be placed on one side of a fairly wide opening, and completely fill underneath the opening following this method. You will notice that the dotted line is raised higher between the windows than the window-sill itself. This is done in order to build up a head or pressure enough at this point to force the concrete under the opening and at the same time take care of the settlement that will take place under the opening.

On the opposite side of the opening you will also note that the dotted line is higher than the window-sill. When the top surface of this concrete is smooth as if a trowel had been drawn over it, the form under the sill is completely filled.

In the past it has been considered poor practice to place walls, slabs and girders on the same day. This is still true unless precautions are taken to place the walls sufficiently in advance that any settlement will take place before placing concrete in the floor system. Normally this would be from one to two hours. With a proper mix this should be sufficient time for settlement and still avoid stiffening of the concrete to the point that a flow line or a cold joint will show at this point. Following this procedure the number of construction joints is reduced. It should be considered on all jobs.

While the same procedure is sometimes followed at the tops of window and door openings I do not believe that this should be done.

I have seen the time for settlement misjudged so many times that I would make a construction joint at this location a requirement. In some cases flow lines or cold joints have been the result, but in most cases cracks have been the result. No one on the job will ever admit the cause, it is always something else.

The location of construction joints should be determined by the architect or engineer, and shown on the drawings, with a clause in the specifications requiring that any changes or additional joints must be approved by the engineer. In the field, special care must be taken at construction joints in both form construction and in placing the concrete.

Where it is possible, horizontal construction joints should be located at rustications or ornamentations, as the joints will be less conspicuous. Window sills and window heads are excellent locations. If possible no lift should be over 10′ in height unless some provisions are made to place concrete at a midpoint from the back of the wall.

Vertical construction joints can be made at almost any control joint location. If this is done a control strip should be used in the face of the wall in order to permit caulking.

Placing of the concrete should proceed in the regular manner to within 8 or 10 in. of the construction joint or top of the wall and be permitted to settle before placing the top layer. This will be no hardship for the contractor as by the time he has completed one layer settlement will have occurred at the starting point so that he can then proceed with the next layer.

The top layer of concrete must be stiffened considerably by reducing the water if a uniform color throughout the height of the lift is to be produced. The stiffer mix will be easy to place as it is near the top of the wall where tamping or vibrating will be easy. It will act as a sponge and draw up some of the surplus water from the concrete in the layer below.

After this layer is tamped and spaded it will be quite plastic and will have approximately the same water-cement ratio as the lower part of the wall. The above procedure avoids the tendency for the top of the wall to be darker and of a poorer grade of concrete.

Even by placing the top lift in this manner, there will be a little mortar rise to the top and this must be disposed of by placing the concrete from ½ to 1 in. above the bottom of the strip or rustication or above the top of the form. After it has stood for about an hour this surplus can be removed to the proper height.

In placing concrete around waste molds or other ornaments, considerable care must be taken. The waste molds being made of fibered plaster are easily damaged and vibrators and puddling sticks must be used with more care. Concrete should be placed in layers not to exceed 1 ft. and each layer thoroughly spaded or puddled before the next layer is placed.

The proper time to clean the forms in order to reuse them is not later, but immediately after they are stripped. At that time the dust or film can be removed very easily with a stiff bristle brush or broom and a thin flat scraper and then the contact surfaces can be touched up with No. 1½ sand-paper.

As stated before, no wire brush should be allowed because they will gouge out the soft fibers in the wood. Then, on the next use the concrete will bond to the forms and when the forms are stripped a rough surface will result.

After they are cleaned the forms should be reoiled, but at no time should there be an excess of oil. This will cause discoloration and with some oils will retard the set of the concrete at the face.

Curing of concrete walls is much discussed but seldom done. The exact manner of curing a job of this type is strictly a matter of economy, as each job presents a different problem. Whatever method is selected, the architect or engineer should see that the walls are kept wet for at least 5 days.

On some jobs the most economical method is to have a man hose the building down. On others it may be more economical to cover the building with a burlap curtain in order to reduce the frequency of wetting. The burlap not only protects the concrete against air and by keeping it wet it keeps the concrete damp. A perforated pipe for sprinkling the concrete is sometimes used. The pipe should be suspended about 1 ft. from the building and in such a way that no drip from the pipe can run on the wall and cause rust streaks. Intermittent wetting and drying of the wall should be avoided.

With proper care, very little patching, if any, should be necessary. We all know that while a patch can be made it is quite expensive, and that the concrete will not be as good as concrete that is not patched. Patches can always be detected sooner or later.

Mortar for patching and for filling tie holes should be made of the same material and the same proportions as used in the concrete except that the coarse aggregate should be omitted and enough white cement substituted for part of the regular portland cement to match the color of the surrounding concrete. The amount of mixing water should be just enough to allow the mortar to stand for at least 1 hour before using. During this time the mortar should be stirred occasionally but without adding water. This is to temper the patching material, or pre-shrink it before it is used.

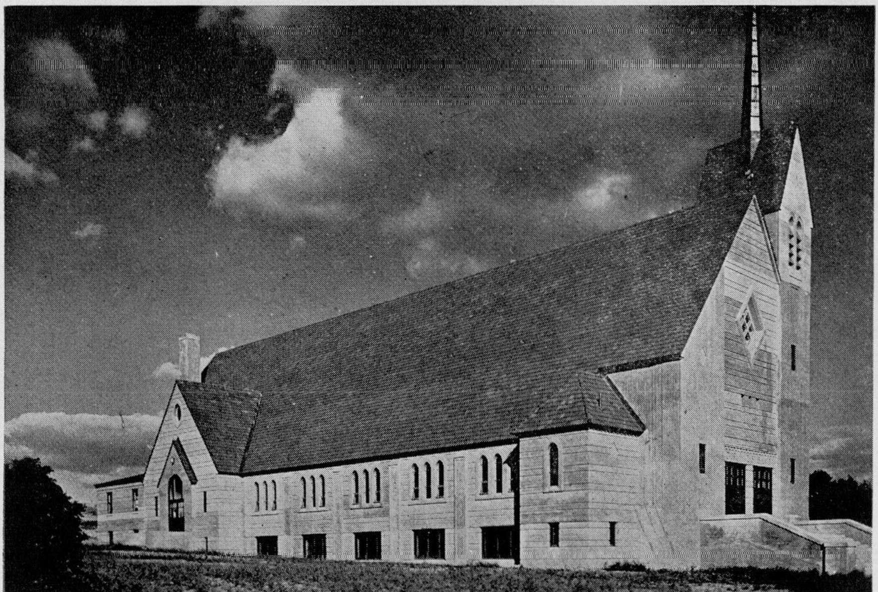
The place to be patched must be wetted to prevent absorption of the water of the patching mortar. The area to be patched should be prepared immediately after the forms are removed by removing all loose particles and chipping to a depth of not less than one inch with edges perpendicular to the surface. Tie holes, if quite small and not tapered, can be patched later but, if large or tapered, they must be patched or filled before the concrete dries out.

A wide range of textures can be produced in concrete, from a very smooth surface to a very rough one showing an exaggerated impression of the grain of the form lumber.

If the holes are made by ties only partly removed they may be filled by tamping in grout. The wall is then rubbed with an abrasive stone, keeping the wall wet during the rubbing process. This will work up a paste on the surface. Most of the paste must be scraped off with the edge of a steel trowel and the remainder spread evenly over the surface with a wood float. Before the paste has thoroughly hardened the surface is rubbed with burlap to insure a smooth texture; being sure that no grout is left on the wall. The wall should then be kept wet for several days.

The best method of clean down is one where no dead mortar is worked up on the wall, or nothing is left on the wall. It is my opinion that a much better job can be had with this method as it will be more durable due to the fact that the skin or surface of the wall has not been broken.

With this method of cleandown two operations may be needed if the walls have a film of oil on the surface resulting from an excess of oil on the forms. The first cleaning will be an acid wash. To do this, thoroughly wet the wall or portions of the wall that will need the wash and while still wet scrub vigorously with a 5 to 10 per cent solution of muriatic acid using a stiff bristle brush. After this be sure to wash all traces of acid from the surface with an abundance of water.



St. Croix Church—Lewiston, Maine.

This operation is only used where an excess oil film is left on the concrete.

The cleandown method described is done in the following way. First, after the form tie holes are all filled, take a fine abrasive stone and remove all fins and spots that project beyond the face, but being careful not to cut beyond the face of the wall. In other words lines are not to be removed as this will change the texture. A grout of fine sand and cement having the consistency of paste should then be applied to the wetted wall. This can be applied with a brush, filling all air bubbles and holes. Immediately after applying the grout float the surface with a wood or fine abrasive stone, scouring the wall vigorously. The grout should then be allowed to harden partially. If it tends to dry out too fast it should be kept wet. When the grout has stiffened so that it will not be pulled out of the holes it should be cut off with the edge of a steel trowel. Next allow the surface to dry thoroughly and then rub it vigorously with a dry piece of burlap to completely remove all of the grout.

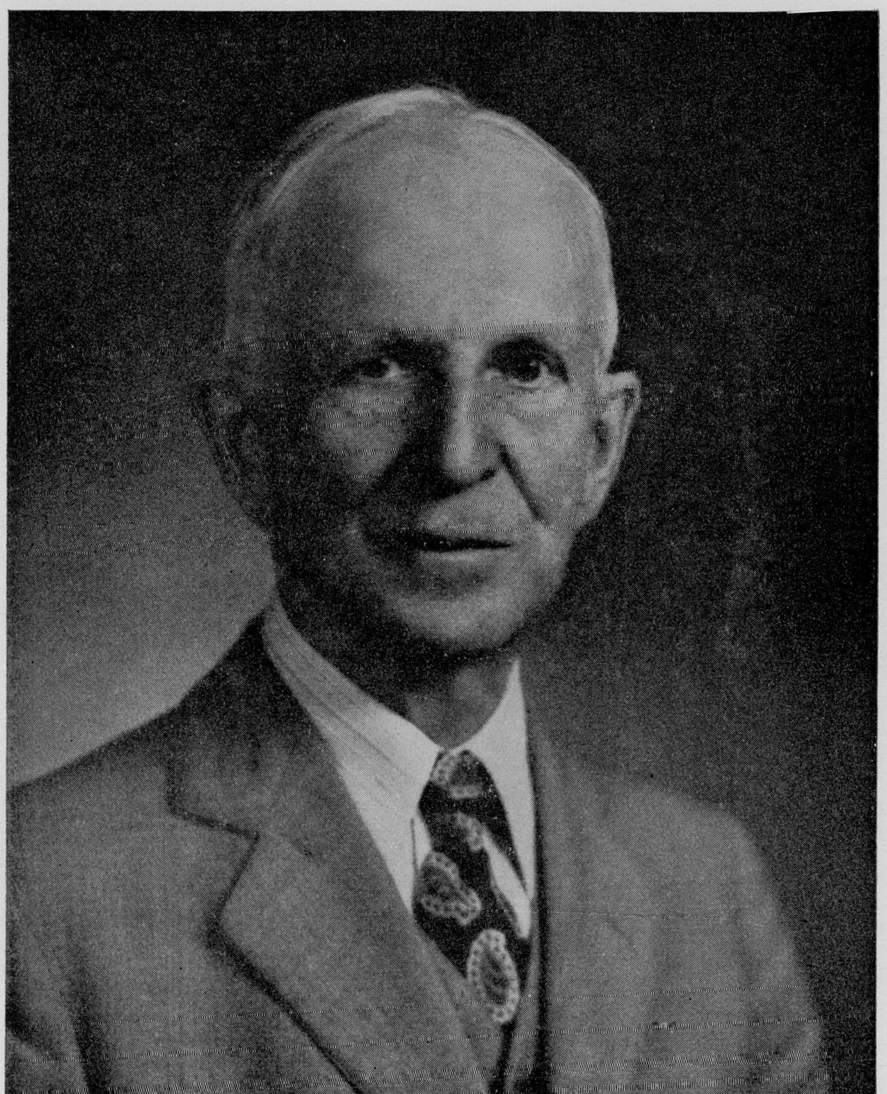
The entire cleaning operation in any area must be finished the same day on which it is started. No grout or film of any kind should be left on the surface. After the building has been cleaned down and if any dark spots or streaks remain they can be removed with a fine hone.

ARTHUR TRUMAN SAFFORD
1867 - 1951

Arthur Truman Safford was born in Chicago, Illinois, on February 9, 1867. He spent the early years of his life in Williamstown, Massachusetts, where his father, Truman H. Safford, was a professor of astronomy. He went to Williams College, graduating in 1887 and three years later received a master's degree. In 1927 he was given an honorary degree of Master of Science. For many years he was secretary of his college class.

After graduation he was employed as an assistant engineer by the Massachusetts State Department of Health from 1887 to 1891, assistant to the city engineer of Newton from 1891-98 on sewer construction and assistant engineer on the Metropolitan Water Supply from 1893-94. In 1894 he became assistant engineer of the Proprietors of the Locks and Canals in Lowell under Hiram F. Mills, becoming chief engineer in 1916, which position he held until 1938. He continued to serve the company as consulting engineer until 1950. The work of engineer of the Proprietors of the Locks and Canals meant the complete operation of the Company including the distribution of the water among the various mills owning the water power leases. It is interesting that after the 1927 flood Mr. Safford decided that the protection afforded by the head walls at the Pawtucket gates, the level of which was originally set by James B. Francis in 1848 when he constructed the famous Francis gate, were not sufficiently high to take possible future floods and they were all raised. His judgment was vindicated in the 1936 flood which would have overtopped the old walls. During his time in Lowell the water wheel installations of nearly all of the mills were modernized and converted into hydro-electric plants, most of them under Mr. Safford's engineering charge.

In addition to his work with the Locks and Canals, Mr. Safford did a great deal of work outside. He was for many years consulting engineer for the Wamesit Power Company in Lowell. He had a large outside consulting practice. He was consulting engineer for the Turner Falls Power & Electric Company in the development of its



Arthur Truman Safford
1867-1951

water power on the Connecticut River, at that time the largest in New England; also for the Amoskeag Manufacturing Company on its hydroelectric development on the Merrimac River at Manchester. For many years he was consulting engineer for the International Paper Company and for many other textile and other mills, cities and towns. He did a great deal in the field of water measurement and distribution, interpretation and valuation of water power leases and water rights all over New England, particularly in Maine and also New York State. At the time of the construction of the Scituate Reservoir of the Providence Water Supply, he was consulting engineer for the mills on the Pawtuxet River affected by the diversion. It was originally proposed that the city should divert all but 12 million gallons a day which should be allowed to flow down the river for the benefit of the mills. Due to his efforts this was increased to 20 m.g.d. This figure of 20 m.g.d. was later adopted for the Quabbin Reservoir. His files show many such interesting hydraulic problems from all over New England, varying from large to small all taken care of with his characteristic thoroughness.

In 1908 Mr. Safford was appointed lecturer at the Harvard Engineering School giving a course in Water Power Engineering which he continued for 13 years. In 1915 and again in 1924 he delivered the Lyman Lectures on water storage at the Sheffield Scientific School at Yale.

He took an active interest in various activities in Lowell. In 1926 when the state set up a Finance Commission for the City, Governor Fuller appointed him chairman. He was trustee and member of the investment committee of the Lowell Five Cent Savings Bank; Trustee of the Lowell Cemetery and the Rogers Hall School and other organizations.

Mr. Safford was very active in the affairs of the Boston Society of Civil Engineers. He was elected a member in 1892. He was director of the Society from 1923 to 1925; Vice president from 1928-30 and president 1934-35. In 1944 he was elected an honorary member. He was awarded the Desmond FitzGerald medal in 1923 for his paper entitled "The Amoskeag Manufacturing Company's Hydroelectric Development." For many years he was chairman of the Committee on Rainfall and Run-off, for which he was awarded the Clemens Herschel prize in 1922. After the Vermont Flood of 1927 he headed the Society's Flood Committee which published its report in 1930, which is one of the notable contributions to the science of flood hydrology.

He was the author of various engineering papers many of which were published in the JOURNAL of the Society. In 1911 he published jointly with Professor H. J. Hughes of Harvard, a textbook entitled "Hydraulics."

He was a member of the American Society of Civil Engineers; the American Society of Mechanical Engineers; New England Water Works Association; American Water Works Association, and of various clubs in Lowell and Boston.

Mr. Safford died on April 3, 1951. He is survived by four sons, Truman H., and Paul C., both of Lowell, Arthur T. Jr., of Hartford, Conn., Charles L. of Forest Hills, N. Y., a daughter, Mrs. Robert Milton of Worcester, and six grandchildren.

Mr. Safford was intimately connected with the hydraulic development of New England where with his wide practice he was very well known. His work was always characterized by a directness and integrity of approach and a soundness of thought which resulted in a solution of any problem in as direct terms as was possible in the case. This quality, with his wide experience in all kinds of problems and excellent engineering judgment, gave all his work an unusually high value. He takes his place as a fitting member of that group of eminent Massachusetts hydraulic engineers starting with James B. Francis who by their character as well as their attainments have done so much in the past for the progress of engineering science and practice and the development of the community.

OF GENERAL INTEREST

The new Hydrodynamics Laboratory of the Department of Civil and Sanitary Engineering was dedicated on the morning of June 4. More than 300 engineers and scientists from all parts of the country and from abroad registered for the dedication ceremonies and participated in the subsequent three-day program entitled "Symposium on Hydrodynamics in Modern Technology". The purpose of this dedication and of the Symposium was oriented towards a comprehensive summary of the parts which analysis, experiment, and practical experience have played in the application of hydrodynamic principles to engineering problems. In order to give an adequate description of the scope of this Symposium, the program as followed from June 4-6 is reprinted below:

PROGRAM

June 4

MORNING SESSION—9:30-12:00
DEDICATION OF HYDRODYNAMICS LABORATORY

Presiding: THOMAS K. SHERWOOD, Dean of Engineering

Address of Welcome:
JOHN B. WILBUR, Head, Department of Civil and Sanitary Engineering

"The New Hydrodynamics Laboratory"—ARTHUR T. IPPEN, Professor of Hydraulics

"The New Ship Model Towing Tank" —GEORGE C. MANNING, Acting Head, Department of Naval Architecture and Marine Engineering

Acceptance of the new Facilities:
JAMES R. KILLIAN, JR., President of M.I.T.

Inspection of the Laboratory

LUNCHEON: 12:30-2:00
GRADUATE HOUSE, CAMPUS ROOM

AFTERNOON SESSION 2:00-5:00
HUNTINGTON HALL, ROOM 10-250

Hydrodynamics and Industry

Chairman: BEAUCHAMP E. SMITH, President
S. Morgan Smith Company
York, Pennsylvania

"Hydrodynamics in Pipe Line Engineering"—S. LOGAN KERR, S. Logan Kerr Company, Inc., Consulting Engineers, Philadelphia, Pennsylvania

"Flow of Multiphase Fluids Through Porous Media"—T. V. MOORE, Manager, Production Research, Standard Oil Development Company; and W. A. BRUCE, Assistant Chief of Research, Carter Oil Company, New York City

"Hydraulic Pumps and Compressors" —RALPH M. WATSON, Assistant to the Vice President in Charge of Engineering, Worthington Pump and Machinery Corporation, Harrison, New Jersey

"Hydraulic Turbines"—FORREST NAGLER, Chief Mechanical Engineer, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

SOCIAL HOUR: 5:30 P.M.

GRADUATE HOUSE, CAMPUS ROOM
DINNER: 6:30 P.M.

Toastmaster: THOMAS C. DESMOND, New York State Senator, Newburgh, New York

Address: KARL T. COMPTON, Chairman of the Corporation, M.I.T.
"Engineering Manpower Trends"

June 5

MORNING SESSION (A) 9:15-12:00
HUNTINGTON HALL, ROOM 10-250
Hydraulics and Public Works
Chairman: BORIS A. BAKHMETEFF
Professor of Civil Engineering
Columbia University, New York City

"Development of Natural Water Resources"—WESLEY R. NELSON, Assistant Commissioner, Bureau of Reclamation, Washington, D. C.

"River and Harbor Improvements"—CLARENCE F. WICKER, Chief, Engineering Division, Philadelphia District, Corps of Engineers, Philadelphia, Pennsylvania

"Hydraulics in Sanitary Engineering"—THOMAS R. CAMP, Camp, Dresser and McKee, Consulting Engineers, Boston, Massachusetts

"Hydraulic Experimentation and Engineering Design"—JOSEPH B. TIFFANY, JR., Assistant Director; and FREDERICK R. BROWN, Chief, Hydrodynamics Branch, Waterways Experiment Station, Vicksburg, Mississippi

MORNING SESSION (B) 9:15-12:00
EASTMAN LECTURE HALL, ROOM 6-120
Hydrodynamics and Naval Architecture
Chairman: Vice Admiral EDWARD L. COCHRANE, USN (Ret.)
Head, Department of Naval Architecture and Marine Engineering, M.I.T., on leave
Administrator, Maritime Administration, Washington, D. C.

"Current Hydrodynamic Problems in Ship Design"—Captain HAROLD E. SAUNDERS, USN (Ret.) Spec. Assist. to Chief, Bureau of Ships, Washington, D. C.

"Progress in the Computation of the Wave Resistance of Ships"—GEORG P. WEINBLUM, David Taylor Model Basin, Washington, D. C.

"Progress in the Computation of the Frictional Resistance of Ships"—KARL E. SCHOENHERR, Dean of the College of Engineering, University of Notre Dame, Notre Dame, Indiana

AFTERNOON SESSION 1:30-4:30
HUNTINGTON HALL, ROOM 10-250
Hydrodynamics and National Defense
Chairman: Rear Admiral CALVIN M. BOLSTER, USN
Office of Naval Research, Department of the Navy, Washington, D. C.

"The Role of Hydraulic Engineering in Land Warfare"—Major General LEWIS A. PICK, Chief of Engineers, Department of the Army, Washington, D. C.

"Hydrodynamics of Undersea Warfare"—Lt. Cdr. ROBERT C. GOODING, Bureau of Ships, Department of the Navy, Washington, D. C.

"Hydrodynamic Problems in Harbors and Coastal Waters"—ALFRED C. REDFIELD, Associate Director, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

4:30—Inspection and Demonstration of the Hydrodynamics Laboratory
Refreshments will be Served

June 6

MORNING SESSION 9:15-12:00
HUNTINGTON HALL, ROOM 10-250
Hydrodynamics Research at M.I.T.
Chairman: MINA REES
Director, Mathematical Sciences Division,
Office of Naval Research,
Washington, D. C.

"Some Aspects of Recent Developments in the Study of Turbulence"—CHIA-CHIAO LIN, Associate Professor of Mathematics

"Turbulent Transfer Processes in Parallel Jets"—ASCHER H. SHAPIRO, Associate Professor of Mechanical Engineering

"The Unsteady Flow Water Tunnel for Boundary Resistance and Cavitation Studies"—JAMES W. DAILY, Associate Professor of Hydraulics; and KENNETH C. DEEMER, Research Associate

"The Effect on Metal Surfaces of Steepfronted Pressure Waves in Liquids"—BRANDON G. RIGHTMIRE, Assistant Professor of Mechanical Engineering

AFTERNOON SESSION 1:30-4:30
HUNTINGTON HALL, ROOM 10-250
Hydrodynamics Research at M.I.T.
Chairman: GEORGE E. RUSSELL, Professor Emeritus of Hydraulics

"Review of progress in the Study of Gravity Waves"—VICTOR P. STARR, Associate Professor of Meteorology

"Quantitative Studies of Supersonic Flow Problems by Hydraulic Analogy"—ARTHUR T. IPPEN, Professor of Hydraulics, and DONALD R. F. HARLEMAN, Assistant Professor of Hydraulics

"New Relationships for the Analysis of Surge Tank Transients"—ALLAN T. GIFFORD, Associate Professor of Hydraulic Engineering, and HENRY M. PAYNTER, Assistant Professor of Hydraulics

"Quantitative Studies of Oxygen Transfer in Water"—LAWRENCE G. CAMPBELL, Research Associate, and ROBERT S. YOSEPH, Research Associate

The Dedication Ceremonies

Dr. Thomas K. Sherwood, Dean of Engineering, presided at the Dedication of the Hydrodynamics Laboratory and Ship Model Towing Tank, housed in the same building, and introduced Dr. John B. Wilbur, Head of the Department of Civil and Sanitary Engineering, to give the address of welcome. Dr. Wilbur expressed briefly the meaning of such a dedication ceremony to the students, staff, and guests, and commented particularly on the spirit which M.I.T. imparts to all those whose careers are moulded within its walls. He concluded his remarks as follows:

"As we meet this morning in this new building of which we are so justly proud, we do not think in terms of the steel and the concrete and the bricks of which it is built, but of the hopes and of the aspirations and of the generosity of those who made it possible. We see in it not only a fine new unit of the Institute's equipment, but an instrument which, under the guidance of capable hands, will open the doors of opportunity to young men as they work here together, learning the fundamentals of today, and extending the frontiers of knowledge for tomorrow.

"This is indeed a happy occasion. And it is a pleasant custom of our way of life, that when we have cause to rejoice, we wish to be surrounded by our friends. Whether it be at Commencement, or in marriage, or on an anniversary, or at a dedication, it is heartening to have with us those friends who in act and spirit have shown that they share with us our hopes and our ideals.

"And so, as we gather here this morning to dedicate this new Hydrodynamics Laboratory and Ship Model Towing Tank, it is my pleasure, on behalf of the Massachusetts Institute of Technology, to figuratively grasp your hand and bid you welcome.

"We are glad that you are with us today."

Dr. Arthur T. Ippen, Professor of Hydraulics, then described in some detail not only the physical layout and equipment of the building, but also the educational and research aims to which it is being devoted, and which are concerned with the flow of liquids in engineering processes and structures. The work in the laboratory is to be integrated into a general education in hydrodynamics and hydraulic engineering by meeting with many specialized interests and receiving locally from other departments of the Institute the benefits of accomplishment in practically all related fields. Dr. Ippen emphasized the part of the laboratory in the training of students, who will be given the widest opportunity to work with the research equipment in the laboratory, as well as with special demonstration and experimental units to be gradually developed towards the most effective educational function. It was pointed out that industry and public agencies can well contribute to this function of the laboratory by confronting the staff members with experiences and problems taken from practice, which then filter gradually through stages of reflection, absorption, and investigation into the teaching process, keeping it up to date and aware of practical requirements.

Professor George C. Manning, Acting Head of the Department of Naval Architecture and Marine Engineering, expressed his satisfaction over the final attainment of a Ship Model Towing Tank, an experimental facility which had been planned and strived for at M.I.T. for many decades. This Ship Model Towing Tank will fill an important part in the training of naval architects, a phase of education in which M.I.T. has long been leading.

[Detailed descriptions of the facilities of the Hydrodynamics Laboratory and of the Ship Model Towing Tank have appeared in the June issue of the *Technology Review* and reprints of these articles by Arthur T. Ippen and Martin A. Abkowitz may be obtained from the Hydrodynamics Laboratory upon request.]

Dean Sherwood finally introduced Dr. James R. Killian, Jr., President of M.I.T., who formally accepted the new laboratory into the growing number of outstanding new research facilities at the Massachusetts Institute of Technology. Dr. Killian spoke of the function of experimental research in our modern technology and stressed particularly the cross fertilization of ideas between different technological fields. It was his hope that the Hydrodynamics Laboratory would satisfy this role of growing importance, similar to the laboratories for Acoustics and Electronics, as well as for Metals Processing, which are now jointly sponsored by several departments.

The guests then inspected in informal groups the great number of experimental research units throughout the laboratory, most of which were explained while in operation. The specific scopes and results attained to date on projects now under way were amplified by means of numerous illustrated posters.

Symposium on Hydrodynamics in Modern Technology

The Symposium dealt with comprehensive phases of technological hydrodynamic problems under four main headings: Hydrodynamics in Industry, Hydraulics and Public Works, Hydrodynamics and Naval Architecture, and Hydrodynamics and National Defense. For each session, engineers and scientists outstanding in their respective fields gave a review of the contributions made by scientific investigations in the past, recounted the present problems faced in practice, and summarized the significant areas for future endeavors. It was felt that these lectures were of considerable interest to the profession in general, and contained a wealth of important material that will therefore be published by the Hydrodynamics Laboratory of the Institute in the near future.

The last day of the Symposium was given over to a review of hydrodynamics research in the various departments at M.I.T., such as the Departments of Mathematics, Mechanical Engineering, and Meterology, as well as of the results achieved so far in the Hydrodynamics Laboratory.

The various congenial social activities were highlighted by an after dinner address of Dr. Karl T. Compton, Chairman of the Corporation of M.I.T., who discussed the rather serious implications of present "Engineering Manpower Trends". The rapid falling off in the number of young engineers expected to graduate during the next few years is in sharp contrast to the increasing demand of our technology for engineering talent. Serious shortages in trained personnel are going to hamper our production efforts unless this trend can be arrested. New York State Senator Thomas C. Desmond acted as

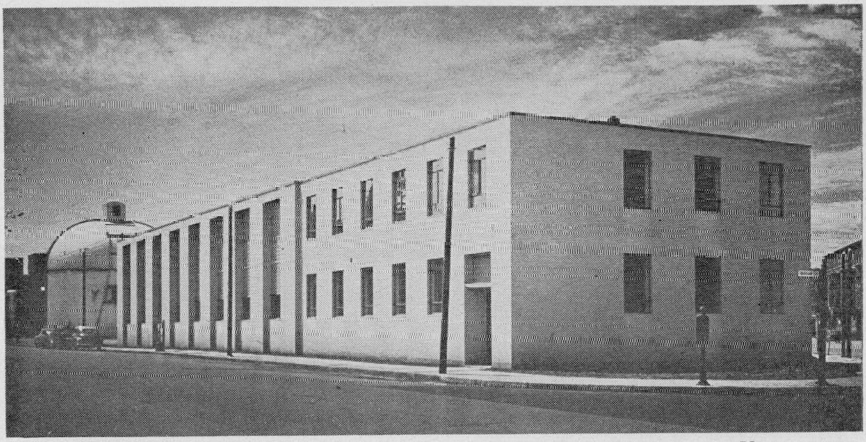


FIG. A.—VIEW OF M.I.T. HYDRODYNAMICS LABORATORY AT CORNER OF VASSAR AND MAIN STREETS.

toastmaster and was instrumental in stimulating extensive discussion from the floor of Dr. Compton's interesting talk.

The New Hydrodynamics Laboratory

The new Laboratory is located at the corner of Vassar and Main Streets in Cambridge as shown in the accompanying exterior view given in Figure A. The building is approximately 190′ × 60′ and, due to its function, was founded on a solid concrete slab 5′ to 6′ in thickness to prevent differential settlement. The building is planned to receive two additional stories and can also be extended westward. A detailed floor plan is shown in Figure B. The space is primarily given over to a large hall with a floor area 120′ × 58″, two stories in height, to be devoted to research set-ups. The necessary water storage tanks, the circulating equipment, as well as the towing tank, are located in the basement. The main circulating pumps, consisting of three double suction, single stage centrifugal pumps, were furnished by the Ingersoll Rand Company of New York and provide a maximum discharge of 15,000 gpm at a head of 40 ft.

Figure C gives a perspective view of the main research laboratory with the equipment now existing as well as that planned for the future. Along the south wall can be seen a long glass-walled flume to be 110′ long, 30″ wide, and 36″ deep. This flume will serve primarily for investigations of hydraulic overflow and underflow structures. It will also be furnished with a wave machine to determine the action of waves on hydraulic structures.

The space in the center background is reserved for a hydraulic model basin in which studies of comprehensive hydraulic problems may be carried out, such as the performance of new structures in rivers, estuaries, harbors, and along the coasts.

On the right hand side of the same view is shown a swing spout arrangement forming part of a calibration system for the various Venturi meters and other water measuring devices to be employed in the laboratory. Volumetric tanks below the floor level serve as primary standards for discharge measurements in this system.

In line with the educational aims of the laboratory, a floor space 31′ × 50′ has been set aside to house smaller

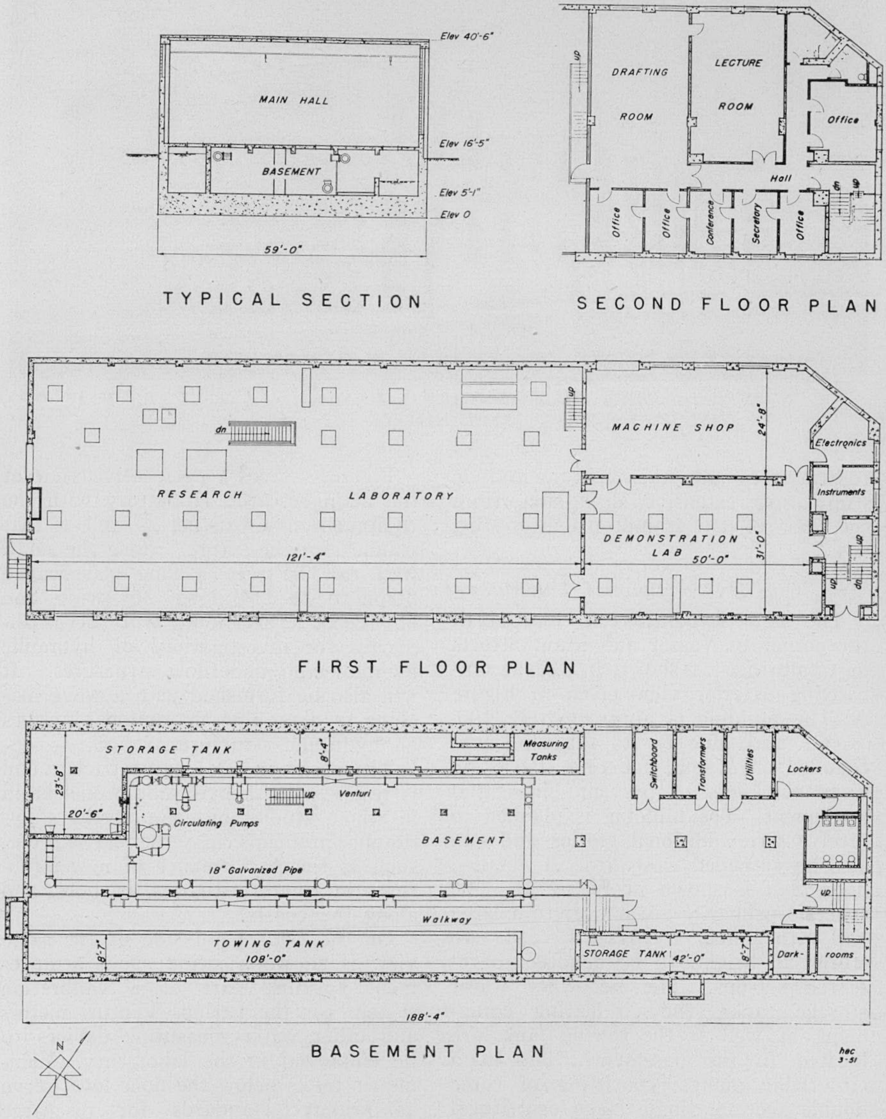


Fig. B.—Floor Plans and Section.

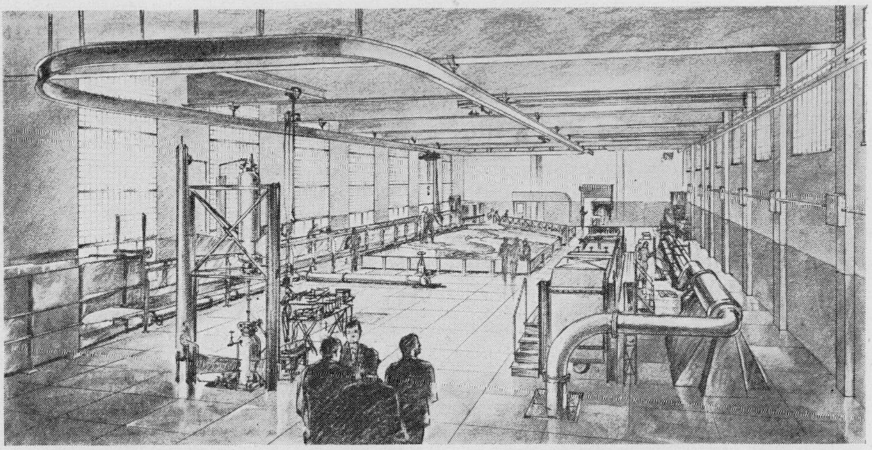


Fig. C.—View of Main Hall with Present and Future Research Equipment.

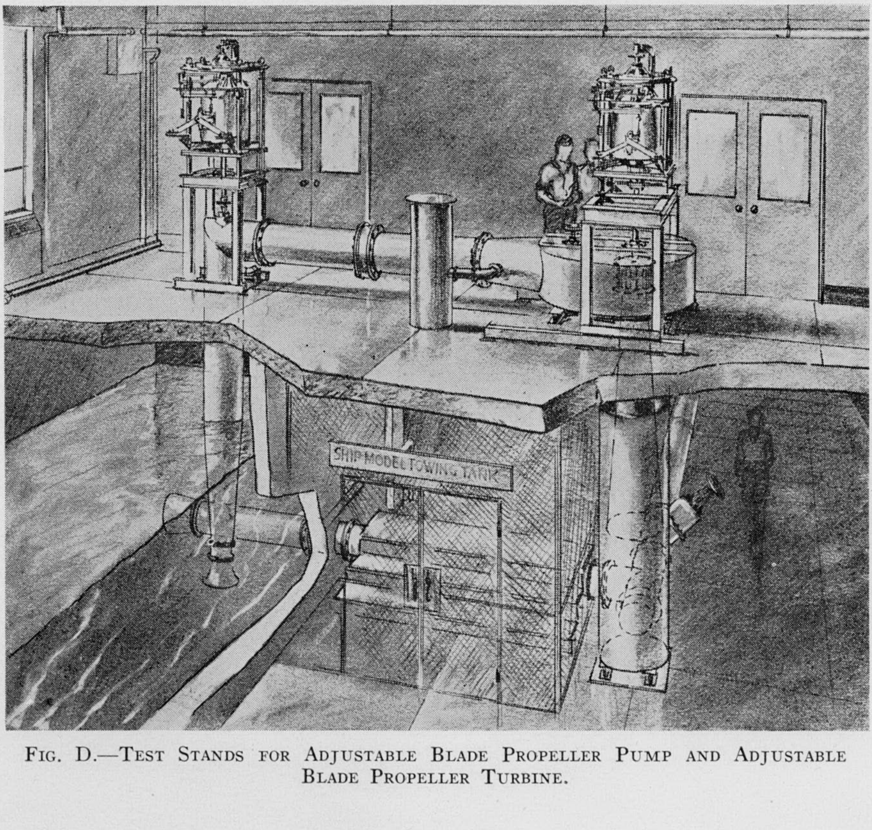


Fig. D.—Test Stands for Adjustable Blade Propeller Pump and Adjustable Blade Propeller Turbine.

demonstration units for the illustration of basic flow phenomena, but flexible and large enough to permit diversified student experiments. One of the largest units in this laboratory is shown in Figure D, illustrating a test stand for hydraulic machinery comprising an adjustable blade propeller turbine and an adjustable blade propeller pump, both mounted with dynamometers. This unit has been donated by the S. Morgan Smith Company of York, Pennsylvania.

The Staff of the Hydrodynamics Laboratory

The staff of the Hydrodynamics Laboratory is already well known to the members of the Hydraulic Section of the Boston Society of Civil Engineers through various contributions made to its activities.

Dr. Arthur T. Ippen is to direct the laboratory under the Department of Civil and Sanitary Engineering. He and Dr. James W. Daily were closely associated with the planning of the building and represent in their primary interests the fields of general fluid mechanics, hydraulic structures, and hydraulic machinery. Professor Allan T. Gifford carries on the work on hydrology and waterpower. Dr. Donald R. Harleman teaches fluid mechanics and experimental hydromechanics. Dr. Henry M. Paynter, in addition to teaching fluid mechanics, has specialized in problems of transient phenomena of flow. Professor Martin A. Abkowitz is in charge of the work with the Ship Model Towing Tank for the Department of Naval Architecture and Marine Engineering.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETING

Boston Society of Civil Engineers

April 25, 1951.—A joint meeting of the Boston Society of Civil Engineers with the Northeastern Section of the American Society of Civil Egineers, and the Transportation Section, BSCE, was held this evening at the Ninety-nine Club, 89 State Street, Boston, Mass.

President, Howard J. Williams of the Northeastern Section, American Society of Civil Engineers, presiding at the Joint Meeting, called upon President John B. Wilbur, of the Boston Society of Civil Engineers to conduct any BSCE matter of business necessary.

President Wilbur called upon Secretary, Robert W. Moir to announce the names of applicants for membership in the BSCE.

President Wilbur then announced that the next meeting of the BSCE would be held on May 16, 1951, at the American Academy of Arts & Sciences, Mr. George L. Wey, Chief Engineer, Port of Boston Authority would address the Society on "The Development of the Port of Boston".

President, Howard J. Williams then introduced the speakers of the evening, Dr. John B. Wilbur and Edward C. Keane, who gave a very interesting illustrated talk on "The Proposed Boston Central Artery".

The meeting was attended by eighty-nine members and guests and after a short discussion was adjourned at 9:15 P.M.

Robert W. Moir, *Secretary*

May 16, 1951.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the American Academy of Arts & Sciences, 28 Newbury Street, Boston, Mass. Due to the absence of President Wilbur the meeting was called to order by Vice-President, Emil A. Gramstorff at 7:00 P.M.

Vice-President Gramstorff announced that the reading of the minutes of the previous meeting would be waived unless there was objection.

It was VOTED "to dispense with the reading of the minutes of the previous meeting."

Vice-President Gramstorff announced the death of the following members:—

Ray L. Schoppe, who was elected a member September 24, 1947 and who died February 27, 1951.

John T. Donahoe, who was elected a member February 18, 1936 and who died March 26, 1951.

Arthur T. Safford, who was elected a member December 21, 1892, elected an Honorary Member January 26, 1943, and who died April 3, 1951.

Arthur L. Sparrow, who was elected a member April 17, 1929 and who died April 6, 1951.

The Secretary announced that the following had been elected to membership:—

Grade of Member:—James Adam, Jr., Adnan N. Adsiz, Thomas T. Amirian, John M. Biggs, Frank L. Bridges, Jr., *James H. Brown, Jr., *Frederick M. Childs, Lionel T.

*Transfer from Grade of Junior

Crepeau, Jeroniman V. Dabrila, *David A. Duncan, *Richard F. Dutting, Otto Germanis, Arnold L. Guild, Joseph A. McCarthy, E. Benson Meservey, Thomas H. Murphy, Clemens Petrelis, William F. Ryan, *Peter C. Tornabene, William Wald, Shih H. Wang.

Grade of Junior Member:—Andres P. Fisichelli, Sanford C. Johnson, Henry H. Yung.

The Secretary announced that application for membership had been received from Frank Holzer.

Vice-President Gramstorff then introduced the speaker of the Evening:—

Mr. George L. Wey, Chief Engineer, Port of Boston Authority

Subject—"Development of the Port of Boston".

A short discussion period followed after which members gathered in the Lounge where a collation was served.

Fifty-one members and guests attended the meeting.

The meeting adjourned at 9:05 P.M.

ROBERT W. MOIR, *Secretary*

STRUCTURAL SECTION

March 14, 1951, at the Society Rooms, Chairman Harding presiding: This was the annual meeting. Officers for the coming year were elected as follows: Chairman, Frank A. Cundari; Vice Chairman, Edward C. Keane; Clerk, Charles H. Norris; Executive Committee, Ruth D. Terzaghi, Jean Ducharme and Edward B. Myott.

The speaker was Mr. T. R. Higgins of the American Institute of Steel Construction, whose subject was "Bolted Structural Joints with Respect to High-Strength Bolts".

The investigation of high-tensile bolts is one of the projects of the Research Council on Riveted and Bolted Structural Joints, of the Engineering Foundation. The Council has recently issued a specification for making connections with these bolts. The bolts cause the joints to hold by friction, not be bearing or by shear in the bolts.

The speaker described the extensive fatigue tests that have been conducted on full-size specimen joints, using the 1/16 inch clearance usually used on riveted work and with unfinished bolts. The tests, also service records on actual installations where high-tensile bolts were substituted for ordinary rivets that had given trouble, showed that the high-tensile bolts are consistently superior to rivets, especially where cyclic loading exists. There has been less slip in properly bolted joints than in riveted joints. While the bolt material costs more than rivet material, the saving in installation cost usually more than offsets the difference in cost of material. Noise is considerably less, and for this reason high-tensile bolts have been used for a number of hospital buildings, and they are now coming into more general use.

Salient points of the new specification of the Council are: (1) High-tensile bolts may be substituted one-for-one for rivets as required under ASTM designation A-141. (2) Bolts should meet ASTM tentative designation A-325 with minimum yield point of 74 to 90 ksi and tensile strength of 105 to 125 ksi. (3) Pattern of bolts should conform with ASA designation B18.2, except there must be a larger fillet under the head. (4) At least one carburized or quenched-and-tempered washer should be used under each nut and bolt head. (5) Bolts should be tightened to 90 per cent of the elastic proof load of the bolts. (6) The inspection procedure should include a check on 5 to 10 per cent of the bolts for proper tension, by loosening and re-tightening.

Ordinary wrenches can be used by trained workmen, but namual torque and power wrenches are recommended.

There was a discussion period that showed a lively interest by the members in this well-presented paper. The attendance was 46.

EDWARD C. KEANE, *Clerk*

HYDRAULICS SECTION

February 26, 1951.—A joint meeting of the Hydraulics Section with the main Society was held at the American Academy of Arts and Sciences.

The meeting was called to order by Mr. Thomas R. Camp, President of the Society at 7:00 P.M. and then turned over to Mr. Elliot F. Childs, Chairman of the Hydraulics Section for the transaction of any business of the Hydraulics Section.

The report of the Nominating Committee for officers of the Section for the ensuing year was read by the Clerk. The slate of officers nominated was as follows:

Chairman—Mr. Gardner K. Wood
Vice Chairman—Mr. Byron O. McCoy
Clerk—Mr. Lincoln W. Ryder
Executive Committee—Mr. Arthur T. Ippen
Mr. Ralph S. Archibald
Mr. Julian H. White

It was voted to approve the Nominating Committee's report, and there being no further nominations from the floor the Clerk was instructed to cast one ballot for the slate as nominated and they were declared elected.

There being no further Section business the meeting was turned back to President Camp for the transaction of further Society business.

Following the completion of the business of the Society a paper on, "New Water Power Development at Holyoke" was presented by Mr. William D. Henderson, Engineer, of Jackson & Moreland. The paper described the early development of water power in Holyoke and the events leading up to the new development. The general layout of the intake power house and tail race was described with discussion of some of the problems encountered. The paper was illustrated with slides.

Following Mr. Henderson's paper, a reel of moving pictures was presented and described by Mr. Robert E. Barret, Jr., President of the Holyoke Water Power Company, showing progress of the construction of the development up to date. Mr. Elliot Lyman of the Holyoke Water Power Company assisted with the projector..

Byron O. McCoy, *Clerk*

May 2, 1951.—A meeting of the Hydraulics Section was held in the Society rooms.

The meeting was called to order by the Chairman of the Section, Gradner K. Wood. The minutes of the previous meeting were read and declared approved as read by the Chairman.

The Chairman introduced the speaker, Mr. Nathaniel Clapp, Project Engineer, Metcalf & Eddy, who spoke on the subject "Hydraulic Features of Cleveland Brook Reservoir Project, Pittsfield, Mass."

The paper was presented in company with many color and black and white slides showing the progress of the construction of the project. The paper covered the Diversion Works, the main Cleveland Brook Reservoir and Dam, Spillway and the several Pipelines.

Attendance was 34.

The meeting adjourned at 9:30 P.M.

Lincoln W. Ryder, *Clerk*

SURVEYING AND MAPPING SECTION

April 5, 1950.—The 11th meeting of this section was held at the Massachusetts Institute of Technology on the above date.

Both Chairman and Vice-Chairman were ill, so your clerk took over the duties of presiding.

There was no business presented before the gathering.

The speaker engaged for the evening was also ill, but sent in his place Mr. Charles B. Foster, from Fairchild Aerial Surveys, Inc. New York.

Mr. Foster read a paper, prepared by the original speaker, on Aerial Mapping.

At the conclusion of the paper, Mr. Elmer C. Houdlette, State Department of Public Works, showed an aerial plan of the area embracing the location of the Newburyport Turnpike cut-off from Danvers to the New Hampshire line and dispersed valuable information on the use of such surveys for this type of planning.

Meeting adjourned at 8:35 P.M.

Attendance—55

EDWARD S. AVERELL, *Clerk*

OCTOBER 25, 1950.—The 12th meeting of this section was held in the Society Rooms, at 7:00 P.M.

The business of the evening was the election of a nominating committee. Those elected were Hugh P. Duffill, Charles O. Baird, and Charles M. Anderson.

The Chairman then introduced Mr. Edward S. Wood, Jr., an Instructor from Harvard Institute of Geographical Exploration. Mr. Wood presented a paper about "Aerial Photography for Highway Location", enlivened with slides.

Attendance—25.

EDWARD S. AVERELL, *Clerk*

JANUARY 17, 1951.—The 13th meeting of this Section was held in the Society Rooms on this date.

The business of the evening was the presentation of the Nominating Committee report. The report was accepted by the Section. The Secretary was instructed to cast one vote for the slate of officers.

The following officers were elected for the current year:

Chairman—John J. Vertic
Vice-Chairman—C. Frederick Joy
Clerk—George W. Hankinson
Executive Committee—
C. Wilbur Nylander, Llewellyn T. Schofield, Herman J. Shea

The chairman then introduced the speaker of the evening, Professor A. H. Holt, Head of the Department of Civil Engineering, Worcester Polytechnic Institute. Professor Holt presented an excellent prepared paper on "The Surveyor and the Law".

The paper was well received and created much interest as indicated by the discussion period.

The attendance was 61.

GEORGE W. HANKINSON, *Clerk*

ADDITIONS

Members

Francis J. Turnbull, Fay, Spofford & Thorndike, 11 Beacon St., Boston, Mass.

Ralph M. Thomas, Corps of Engineers, N. E. Div., 857 Commonwealth Ave., Boston, Mass.

Julio F. Xavier, Corps of Engineers, N. E. Div., 857 Commonwealth Ave., Boston, Mass.

Robert E. Steacy, U. S. Geol. Survey, 939 P. O. Bldg., Boston, Mass.

June Brevdy, Corps of Engineers, N. E. Div., 857 Commonwealth Ave., Boston, Mass.

John R. Snell, Consulting San. Engr., 128 E. Emerson St., Melrose, Mass.

John S. Lovewell, Metcalf & Eddy, 1300 Statler Bldg., Boston, Mass.

Joseph A. Dunn, Hume Pipe of New England Inc., Swampscott, Mass.

Robert W. Butler, Fay, Spofford & Thorndike, 11 Beacon St., Boston, Mass.

Joseph Bornstein, U.S. Soils Conservation Service, Essex, Mass.

Darel A. Root, Camp, Dresser & McKee, 6 Beacon St., Boston, Mass.

Donald R. Harleman, Hydrodynamics Lab., M.I.T., Cambridge, Mass.

Martin F. Cosgrove, Const. Div. Met. Dist. Comm., 20 Somerset St., Boston, Mass.

Arthur J. Bilodeau, Fay, Spofford & Thorndike, 11 Beacon St., Boston, Mass.

John F. Glacken, Water Department, Cambridge, Mass.

Herbert G. Keating, Fay, Spofford & Thorndike, 11 Beacon St., Boston, Mass.

William F. Ryan, Stone & Webster Engr. Corp., 49 Federal St., Boston, Mass.

William Wald, Sumner Schein, 333 Washington St., Boston, Mass.

Arnold L. Guild, Stewart Associates, Cambridge, Mass.

Joseph A. McCarthy, Lawrence Experiment Station, Lawrence, Mass.

James Adam, Jr., Jackson & Moreland, 31 St. James Ave., Boston, Mass.

John M. Biggs, 1-251, Mass. Institute of Technology, Cambridge, Mass.

Thomas T. Amirian, Perry, Shaw, Hepburn & Dean, Boston, Mass.

Frank L. Bridges, W. B. Parsons Company, 10 High Street, Boston, Mass.

Clemens Petrelis, Jackson & Moreland, 31 St. James Ave., Boston, Mass.

Adnan N. Adsiz, Jackson & Moreland, 31 St. James Ave., Boston, Mass.

Lionel T. Crepeau, G. Nelson Perry Company, Cornhill, Boston, Mass.

Richard F. Dutting, Corps of Engineers, N. E. Div., 857 Commonwealth Avenue, Boston, Mass.

Peter C. Tornabene, Tornabene Bros. Co., Newton, Mass.

James H. Brown, Jr., Anderson Nichols Company, Boston, Mass.

E. Benson Meservey, Thos. Worcester Inc., 84 State Street, Boston, Mass.

Junior Members

Willard R. Bliss, New England Power Service Company, 441 Stuart St., Boston, Mass.

Kustutis P. Devenis, Chas. A. Maguire & Associates, 294 Washington St., Boston, Mass.

James R. Cass, Jr., Fay, Spofford & Thorndike, 11 Beacon St., Boston, Mass.

Richard M. Power, Mass. Dept. Public Health, State House, Boston, Mass.

Sanford Joynson, Jackson & Moreland, 31 St. James Avenue, Boston, Mass.

Arthur L. Quaglieri, 56 Woodbine Street, Boston 19, Mass.

DEATHS

Ray L. Schoppe, Feb. 27, 1951
John T. Donahoe, Mar. 26, 1941
Arthur T. Safford, Apr. 3, 1951
Arthur L. Sparrow, Apr. 6, 1951
Edward L. Moreland, June 17, 1951

BOSTON SOCIETY OF CIVIL ENGINEERS

715 Tremont Temple, Boston, Mass.

ORGANIZED JULY 3, 1848

1848 BOSTON SOCIETY OF CIVIL ENGINEERS

ACTS OF INCORPORATION

AN ACT

To Incorporate the Boston Society of Civil Engineers

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

Section 1. George M. Dexter, Simeon Borden, William P. Parrott, their associates and successors, are hereby made a corporation by the name of "The Boston Society of Civil Engineers," for the purposes of promoting science and instruction in the department of Civil Engineering, with all the powers and privileges, and subject to all the duties, liabilities, and restrictions set forth in the forty-fourth chapter of the Revised Statutes.

Section 2. The said corporation may hold real and personal estate not exceeding in amount twenty thousand dollars, and the funds or property thereof shall not be used for any other purpose than those declared in the first section of this act.

[Approved by the Governor, April 24, 1851.]

GEORGE S. BOUTWELL.

AN ACT

To Authorize the Boston Society of Civil Engineers to Hold Additional Real and Personal Estate

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by authority of the same, as follows:

Section 1. Section two of chapter sixty-nine of the acts of the year eighteen hundred and fifty-one is hereby amended by striking out the word "twenty," in the second line, and inserting in place thereof the words, "two hundred" so as to read as follows: Section 2. The said corporation may hold real and personal estate, not exceeding in amount two hundred thousand dollars, and the funds or property thereof shall not be used for any other purpose than those declared in the first section of this act.

Section 2. This act shall take effect upon its passage.

[Approved by the Governor, March 12, 1902.]

W. MURRAY CRANE

CONSTITUTION AND BY-LAWS

PREAMBLE

The members of the Boston Society of Civil Engineers, in accordance with their charter and for the more effectual execution of the design of their institution, establish and ordain the following Constitution and By-Laws for the government of said Society.

CONSTITUTION

Adopted June 15, 1910*

Article I—Objects

The objects of this Society are: the professional improvement of its members, the encouragement of social intercourse among engineers and men of practical science, and the advancement of engineering. For the promotion of these objects, stated meetings of the Society shall be held and a library maintained for the use of its members.

Article II—Membership

The Society shall consist of Members, Honorary Members, Life Members, Junior Members, Student Members and Associates.

Members shall be civil, mechanical, mining or electrical engineers, or other persons belonging to a technical profession, not less than twenty-four years of age, who have been in the active practice of their profession for at least four years. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

Honorary Members shall be persons of eminent scientific attainments whom the Society shall deem worthy of the distinction.

Life Members shall be members who have paid dues for forty years, or who have reached the age of seventy years and have paid dues for thirty years.

Junior Members shall be persons engaged in the active practice of some branch of engineering or other technical profession, or graduates of a school of engineering of recognized standing. They shall be not less than twenty years of age and their connection with the Society shall cease at age twenty-eight unless they shall have been transferred to another grade. The Board of Government, for reasons which it may deem sufficient, may waive the age limit.

Student Members shall be students in a school of engineering of recognized standing. Their membership shall cease at the annual meeting following the termination of their school work, unless they shall have been transferred to another grade of membership.

Other persons interested in the objects of the Society and desirous of being connected with it shall be eligible as Associates.

The members of all grades shall be entitled to all privileges of the Society except the right to vote and to hold office, which rights shall be limited to Members and Life Members; provided, however, that such Members as may be elected Honorary Members shall retain the right to vote and to hold office.

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*Amended May 18, 1932, in Article II.
Amended Feb. 19, 1936, in Article II.
Amended Feb. 17, 1943, in Article III.
Amended Mar. 15, 1950, in Article II, III, IV.

Article III—Officers

The officers of the Society shall consist of a President, two Vice-Presidents, a Secretary, a Treasurer and four Directors. They shall be elected at the Annual Meeting in the manner established in the By-Laws; shall assume their duties at the close of said meeting; and shall hold office until their successors are duly chosen. The President, Secretary and Treasurer shall be elected for one year, the Vice-Presidents and Directors for two years, one Vice-President and two Directors being elected each year.

The officers with the three latest Past Presidents who continue to be members of the Society and are available for service shall constitute the Board of Government which shall have general management of the affairs of the Society.

In case of a vacancy in the office of President the senior Vice-President and the junior Vice-President shall succeed to the office in the order stated. In case of a failure in the succession, the latest Past President who is a member of the Society and willing to serve shall act as President.

In the case of a vacancy in the office of Secretary or Treasurer, the Board of Government may fill the office for the unexpired term.

In case of a vacancy in another office, provisions shall be made at the time of the Annual Election so that all offices shall then be filled.

Article IV—Meetings—Quorum

Meetings of the Society shall be held at such times as may be prescribed by the By-Laws.

The regular meeting in March shall be the Annual Meeting for the election of officers and for the hearing of the annual reports.

Twenty-five voting members shall constitute a quorum for the transaction of business.

Article V—Amendments—Endorsements

Proposed amendments to this Constitution shall be first submitted in writing to the Secretary, endorsed by at least five voting members of the Society. The Board of Government shall designate some subsequent regular meeting, not later than four months from the date of the receipt of the petition, for discussion or amendment of the proposed amendment and shall so signify in the notice for said meeting. This notice shall contain a copy of the proposed amendment. If the proposed amendment in its original or amended form, shall be adopted by a majority of the members present and voting, it shall be forthwith submitted as adopted, in the form of a letter ballot to the voting members for final action. The letter ballot shall be accompanied by a notice of the date of the meeting at which the ballot will be canvassed, which date shall be not less than three weeks later than the date of its issue. An affirmative vote of two-thirds of all ballots cast shall be necessary to the adoption of any amendment.

The Society shall not endorse any action except in the manner prescribed for amendments to the Constitution.

BY-LAWS

ADOPTED JUNE 15, 1910*

1. **Meetings.**—Regular meetings of the Society shall be held on the fourth Wednesday in January and September and on the third Wednesday of the other months, excepting July and August, unless otherwise authorized by the Board of Government.

2. **Order of Business.**—The following order of business shall be observed at all regular meetings unless set aside by a vote of members present:—

(1) Reading of the record of the previous meeting.
(2) Business and reports of committees.
(3) Literary exercises, to begin not more than one hour after the meeting is called to order.
(4) Unfinished business.

3. **Special Meetings.**—The President may call meetings of the Society when he deems it expedient, and shall do so at the written request of ten voting members, stating the purpose of such meeting. No business shall be transacted at a special meeting except that stated in the notice thereof.

4. **Committees.**—Committees and membership thereto shall be appointed by the President with the approval of the Board of Government. The term of all committees, except the Freeman Fund Committee, shall expire at the Annual Meeting.

5. **Nominating Committee and Election of Officers.**—Whenever officers of the Society are to be elected, nominations shall be made by a Nominating Committee. This committee shall consist of the three latest Past Presidents who continue to be members of the Society available for service and are not members of the Board of Government, and six elective members, three of whom shall be elected at each annual meeting to serve two years. At the time of the Annual Election the Nominating Committee shall make nominations to fill vacancies in any office or in the Nominating Committee.

The Nominating Committee shall organize and act under its own rules. It may make nominations whether at the time it consists of nine members or of less, but the approval of at least two-thirds of the members of the Nominating Committee shall be required for a nomination.

Whenever a President, Vice-President, Director, Secretary or Treasurer is to be elected, the Nominating Committee shall nominate one candidate for each office to be filled. Whenever a member of the Nominating Committee is to be elected, the Nominating Committee shall nominate two candidates for each office to be filled.

The Nominating Committee shall file with the Secretary a list of its nominations in the form of a report accompanied by the written consent of each nominee.

The Secretary shall transmit by mail the list of nominees to each member of the Society at least nine weeks before the annual meeting.

An additional nomination for any office may be made by any twenty-five voting members of the Society who sign a nomination paper to that effect and file it with the Secretary at least six weeks before the date of the Annual meeting, accompanied by the written consent of the nominee.

At least four weeks before the day of the annual meeting, the Secretary shall send to each member of the Society a letter ballot bearing the names of all nominees. Ballots shall provide space for entering additional names by the voters and shall state the hour at which polls will close on the day of the annual meeting.

When returned to the Secretary, each ballot shall be enclosed in two envelopes, the inner one to be blank, and the outer one to be endorsed by the member's signature. The President shall appoint two tellers who shall canvass all ballots and the results shall be announced at the annual meeting.

The candidate for any office receiving the largest number of legal votes by letter ballot shall be elected. In the event of a tie, the meeting shall elect by ballot from among the candidates ties, a majority of the votes cast being required for election.

6. **Duties of Officers.**—The President shall have general supervision of the affairs of the Society. He shall preside at all meetings of the Society and of the Board of Government at which he may be present. He shall deliver an address at the Annual Meeting.

The Vice-Presidents in order of seniority shall preside at meetings in the absence of the President.

The Secretary, under the direction of the President and Board of Government, shall be the executive officer of the Society. He shall keep records of all meetings of the Society and of the Board of Government; shall receive all fees, dues and other moneys due the Society (except the income on the permanent fund) and transmit the same monthly to the Treasurer.

The Treasurer, under the direction of the President and Board of Government, shall be charged with the custody and investment of all funds of the Society. The John R. Freeman Fund, however, shall be administered by the Freeman Fund Committee. The Treasurer shall file annually an approved surety bond in an amount to be determined by the Board of Government, the premium on said bond to be paid from the Society's funds. He shall receive all funds transmitted to the Secretary and shall pay all bills or other indebtedness of the Society when properly approved by the President. He shall keep an accurate record of all receipts and disbursements and of all property of the Society in his charge and shall render a report of same at the Annual Meeting.

A committee consisting of two Directors, to be appointed by the President, shall audit the accounts of the Secretary and Treasurer.

The Board of Government shall have general management of the affairs of the Society in conformity with the Constitution and By-Laws. It shall hold stated meetings at least once in every month, excepting July and August, and at such other times as it may determine or when called by the President. Five members shall constitute a quorum for the transaction of business. The Board of Government shall direct the investment and care of the funds of the Society; shall order all ordinary or current expenditures; shall fix the salaries of the Secretary and Treasurer; shall provide for the exercises at the meetings; shall act upon applications for membership as hereinafter provided; shall examine all papers submitted with reference to their fitness for presentation to the Society and for publication; and shall report at each Annual Meeting. To perform these duties it may make such rules and regulations, within its powers, as it may deem necessary; and may appoint committees from its members and delegate to them such of its powers as it may deem expedient, provided, however, that any action of a committee unfavorable to any member shall be reported to the whole Board for final action. The Board of Government shall appoint from its members, or from the members of the Society at large, a Committee on Publication, which shall have charge of the publication of all papers and transactions of the Society.

7. **Election of Members.**—Honorary Members shall be proposed by at least ten voting Members not members of the Board of Government and shall be elected by written ballot by the Board. The affirmative votes of at least eleven members of the Board of Government shall be necessary for election. A person

elected an Honorary Member shall be promptly notified thereof by letter. The election shall become void if an acceptance is not received within six months after the mailing of such notice.

Names of members eligible to become Life Members shall be submitted to the Board of Government by the Secretary each year at the meeting of the Board immediately preceding the Annual Meeting. Such members shall be recorded as Life Members and their names shall be announced at the Annual Meeting.

An application for admission to the Society as a Member, Junior Member, or Associate, or for transfer from one grade to another shall contain over the candidate's signature a statement of his age, residence, and qualifications for membership, and a promise that he will conform to the requirements of membership if elected. The applicant shall furnish as references the names of at least four voting members to whom he is personally known. Each member listed as a reference shall be requested by the Secretary to address a letter to the Board of Government on a form prescribed by said Board stating the extent of the writer's personal knowledge of the applicant and of his professional work and character. If less than four of the references furnish the requisite information the Secretary shall call upon the applicant for additional names, and not until written communications shall have been received from at least four voting members shall the application be considered by the Board.

Each application for admission (except to the grade of Student Member) or for transfer shall be referred to the membership qualifications committee for investigation. A personal interview may be required where deemed advisable. At the meeting of the Society next following receipt of the application, the name of the applicant shall be announced with a request that members transmit to the Board any information which may be of assistance in the consideration of the application. Not sooner than ten days after said announcement, the membership qualifications committee shall consider the application together with any information regarding the applicant that may have been received, shall classify the applicant and report their recommendations to the Board, in writing. Thereafter, the Board shall consider the application and shall vote thereon by letter ballot. The votes of at least two-thirds of the members of the Board of Government shall be required to constitute an election. Two or more negative votes shall preclude election. The name and business affiliation of each newly elected member shall be published in the Journal.

An applicant for admission to the Grade of Junior Member who is a graduate of a school of engineering of recognized standing shall furnish the names of four voting members to whom he is personally known, or in lieu of two of those members, the names of two of his professors.

An applicant for admission to the grade of Student Member shall submit a statement that he is a bona fide student in the engineering school which he is attending. This statement shall be attested by the Dean, Registrar, or other officer of the institution acceptable to the Board of Government.

A committee of three members of the Board of Government shall be appointed by the President each year to consider applications for admission or for transfer and to recommend appropriate action to the Board.

Each elected candidate shall be duly notified of his election; shall be furnished a copy of the Constitution, By-Laws and Code of Ethics, to which he shall subscribe; and shall pay his entrance fee unless such payment shall have been waived by a provision of these By-Laws. If these provisions are not complied with within three months from the notification of the election, such election shall be void unless, for special reasons, the time shall be extended by the Board of Government. Membership of any person shall date from the day of his election.

A rejected applicant may renew his application for membership or for transfer at any time after the expiration of one year from the date of the ballot rejecting his previous application.

8. **Journal.**—Each member and each student chapter shall receive the JOURNAL of the Boston Society of Civil Engineers as a privilege of membership.

Student Chapter members may obtain the JOURNAL by subscription at the rate of $1.50 per year.

9. **Fees and Dues.**—The entrance fee for Members and Associates shall be ten dollars, and for Junior Members, five dollars; except that for members of the armed forces of the United States and for employees of other permanent agencies of the Federal Government who are subject to transfer the entrance fee shall be waived. There shall be no entrance fee for Student Members. There shall be no fee for transfer to a higher grade.

The annual dues, payable in advance at the Annual Meeting, shall be as follows: by Resident Members and Associates, ten dollars; by Non-Resident Members and Associates, six dollars; by Resident Junior Members, five dollars; by Non-Resident Junior Members, four dollars; and by individual Student Members, two dollars and a half. The members of any grade except that of Student, residing within thirty miles of City Hall of Boston, shall be considered as Resident, and those beyond that limit as Non-Resident. New Members elected during the period from the close of the Annual Meeting to June inclusive shall pay full year's dues; members elected during the period from July to December inclusive shall pay one-half year's dues for that fiscal year; members elected during the period from January to the Annual Meeting inclusive shall be exempt from dues during the remainder of that fiscal year. The fiscal year shall commence at the close of the Annual Meeting.

Honorary Members shall not be subject to the payment of fees, dues, or assessments. Life Members shall be exempt from the payment of dues.

Each Student Chapter shall pay annual dues of ten dollars at the beginning of the chapter year.

Three dollars of the dues or such portion thereof as may be required, paid by each Student Chapter and each member except Student Members, shall be applied annually to the payment of a subscription to the JOURNAL of the Boston Society of Civil Engineers. There shall be no charge for the JOURNAL to Honorary Members, Life Members and Student Members.

The Board of Government, for such reasons as it may deem sufficient, may remit the dues in any current year of any member whom it may find to be unable to pay the same. No record is to be made of the name of such member, but the number of such cases shall be reported to the Society annually.

10. **Permanent Fund.**—There shall be a fund called the Permanent Fund, to which shall be added all money received for entrance fees and all income from investments of the fund. In any fiscal year of the Society the income from the Permanent Fund, upon vote of the Board of Government, may be transferred to the current fund for the payment of current expenses to the extent necessary to maintain the current fund. No other sum shall be appropriated from the Permanent Fund except in the manner prescribed for amending the By-Laws. Any such appropriation or any part thereof not used within three years shall be returned to the Fund.

11. **Resignation of Membership.**—Any person whose indebtedness to the Society has been fully paid may withdraw from membership by notifying the Secretary. Any person so resigning his membership may, at the discretion of the Board of Government, be reinstated without again paying the entrance fee.

12. **Forfeiture of Membership.**—Ten months after the Annual Meeting, the Secretary shall notify each member who has not paid his dues for the current year, that unless same are paid within thirty day, his membership in the Society shall cease. Unless payment is so made his name shall be dropped from the list of members. The Board of Government may, however, at its discretion reinstate such persons on the payment of all arrears.

13. **Expulsion of Members.**—A member of any grade may be expelled from the Society for proper cause. Such cause shall be determined by the Board of Government, and shall include—without limitation thereto—unprofessional conduct, unethical practice, or violation of the Code of Ethics of the Boston Society of Civil Engineers.

Any three members of the Society, other than members of the Board of Government, shall have the right to present to the Board of Government any information regarding the conduct of any member which is considered to constitute proper cause for expulsion. The communication shall be in writing, properly documented and authenticated.

The Board of Government shall consider the matter promptly at the time of regular or special meetings. All actions shall be based upon an affirmative vote of at least nine members of the Board of Government. All ballots shall be made in writing and a numerical count thereof shall be recorded. The Board of Government shall have the right to carry on an investigation into the conduct of a member to such extent and by whatever means it shall deem appropriate, and may request the member whose conduct is under investigation to appear before it for interrogation.

If after considering the matter, the Board of Government deems it best, it shall advise the member that his resignation will be accepted. The member shall be furnished a statement of the charges against him. He shall be allowed reasonable time to prepare a defense, and be given an opportunity to appear before the Board of Government if he so desires. The Board of Government may then pass finally upon the matter and, if the resignation has not been tendered or a satisfactory defense made, may expel the member, in which case he shall be so notified and his membership terminated.

14. **Sections.**—The Board of Government may establish Sections for the consideration of special branches of engineering. Such Sections shall in all cases be known as "The (name) Section of the Boston Society of Civil Engineers", and shall consist of not less than ten members of the Society.

Unless a section is in active operation within three months from the date of its establishment the authorization for its formation shall be void.

Papers read before sections and discussions thereon may be published in the same manner and subject to the same conditions as papers read before the Society.

All sections shall be governed by the Constitution and By-Laws of the Society, so far as applicable, but they shall be entitled to make additional by-laws for their own use and government; provided that said additional by-laws be not inconsistent with the Constitution and By-Laws of the Society, and that they be filed with and approved by the Board of Government.

The officers of each section shall be a Chairman, Vice-Chairman and Clerk, who shall be elected by the members of the Section annually.

The general government of each section shall be vested in an Executive Committee, consisting of the officers of the Section, three additional members of the Section who shall be elected annually, and the President of the Society, ex-officio.

The officers of sections may expend such sums for the expenses of meetings as may be appropriated by the Board of Government.

The Chairmen of sections shall be priviledged to attend the regular meetings of the Board of Government, but shall have no vote.

Any section may be abolished by the Society by a two-thirds vote of all the voting members present at any regular meeting, upon recommendation of the Board of Government due notice of such recommendation having been sent with the notice of the meeting to each member of the Society.

All members of the Society shall be privileged to become members of sections upon application on a form obtainable from the Secretary of the Society. The Secretary shall send such form to each newly elected member of the Society with the notice of his election.

Resignations, forfeiture of membership, or expulsion of members of Sections shall be governed by the same conditions and methods of procedure as apply to members of the Society.

15. **Student Chapters.**—The Board of Government may upon written request of the Dean or other acceptable officer of an engineering school of recognized standing, establish a student chapter at such school. The student chapter shall be known as "The (name of school) Student Chapter of the Boston Society of Civil Engineers".

Membership in a student chapter shall be limited to Student Members of the Boston Society of Civil Engineers or students eligible for such membership, who are in attendance as students at the school sponsoring the chapter. One or more members of the teaching staff who are members of the Boston Society of Civil Engineers other than Student Members, shall serve as advisors to the chapter.

A student chapter shall be considered active in any scholastic year when there are six or more active members. If a student chapter shall be inactive for two successive scholastic years it shall be considered discontinued.

Papers read before student chapters and discussions thereon may be published in the same manner and subject to the same conditions as papers read before the Society.

All student chapters shall be governed by the Constitution and By-Laws of the Society so far as applicable, but they may adopt additional by-laws for their own use and government, provided that said additional by-laws be not inconsistent with the Constitution and By-Laws of the Society and that they be filed with and approved by the Board of Government.

The officers of each student chapter shall be a Chairman, Vice-Chairman and Clerk-Treasurer, who shall be elected annually by the members of the chapter. The term of office shall be for one year and shall commence at a date selected by the student chapter and approved by the Board of Government.

It shall be the duty of the Clerk-Treasurer to transmit to the Secretary of the Society: Chapter dues at the beginning of the chapter year; minutes of each meeting of the chapter, following said meeting; an annual report at the close of the chapter year.

Any student chapter may be abolished by a two-thirds vote of the Board of Government.

Each student chapter shall receive one subscription of the JOURNAL.

16. **Amendments.**—An amendment to the By-Laws may be made by a two-thirds vote of the members present and voting, cast in favor of such amendment at each of two successive regular meetings, due notice of the proposed amendment having been sent to each member with the notices of the meetings.

BY-LAWS OF THE SECTIONS
of the
BOSTON SOCIETY OF CIVIL ENGINEERS

Sections Organized

Sanitary Section	January 27, 1904
Structural Section**	May 19, 1920
Transportation Section*	May 1, 1924
Hydraulics Section	May 1, 1940
Surveying and Mapping Section	April 30, 1947

Adopted by the Sanitary Section, Structural Section, Transportation Section, and Hydraulics Section.

(Approved by the Board of Government March 21, 1934)
(Amended April 8, 1946)

ARTICLE I—OBJECTS

SECTION 1. The objects of the Section shall be the advancement of knowledge relating to the science and practice of engineering the professional improvement of its members, the encouragement of the presentation of papers and informal discussion of engineering topics, and the opportunity for social intercourse among its members.

ARTICLE II—MEMBERSHIP

SECTION 1. Members of the Boston Society of Civil Engineers in all grades shall be entitled to membership in the Section upon making written application to the Executive Committee of the Section.

SECTION 2. Eligibility to office and the right to vote shall be limited to the membership of the Section.

SECTION 3. Members of the Society in all grades, who are not enrolled as members of the Section, shall be entitled to attend all meetings of the Section and take part in the discussion of professional subjects, but shall have no vote.

ARTICLE III—OFFICERS

SECTION 1. The officers of the Section shall be a Chairman, Vice-Chairman and Clerk. The general government of the Section shall be vested in an Executive Committee, consisting of the President of the Boston Society of Civil Engineers, the Chairman, Vice-Chairman, Clerk and three other members of the Section.

SECTION 2. The Chairman of the Section shall represent the Section at the meetings of the Board of Government of the Boston Society of Civil Engineers, with the privilege accorded under its By-Laws.

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*Originally established in 1924 as Highway Section, re-named Transportation Section April 8, 1946.

**Originally established in 1920 as Designers Section; re-named Structural Section November 19, 1947.

SECTION 3. The term of office of all officers and committees shall be one year but shall continue until their successors are elected.

SECTION 4. All officers and committees shall assume their duties immediately after the close of the meeting at which they have been elected.

SECTION 5. Vacancies occurring in any office may be filled by ballot at the first meeting after notice of the same has been sent to each member, a majority of the votes cast being necessary to elect.

ARTICLE IV—MANAGEMENT

SECTION 1. The Chairman shall have general supervision of the affairs of the Section. He shall preside at meetings of the Section. In case of his absence or a vacancy in his office, the Vice-Chairman shall discharge his duties.

SECTION 2. The Executive Committee shall have control of the management of the Section, subject to the action of the Section at any meeting, and shall make the necessary arrangements for all meetings. All questions in Executive Committee shall be decided by a majority vote, and four members shall constitute a quorum. Meetings of the Executive Committee shall be held at the call of the Chairman, or, in his absence or inability to serve, at the call of the Vice-Chairman.

SECTION 3. The Clerk shall keep the records of the meetings of the Section and of the Executive Committee, and perform such other duties as are herein prescribed and as may be required by the Executive Committee. He shall prepare and transmit to the Secretary of the Boston Society of Civil Engineers notices of all meetings, copies of the records of all meetings and of all papers and discussions.

SECTION 4. No expenditure shall be made or financial obligation incurred by any officer or committee of the Section, for which the Society will be responsible, without previous authorization by the Board of Government or President of the Society.

ARTICLE V—MEETINGS

SECTION 1. The annual meeting of the Section, at which the annual reports for the preceding year shall be presented and the officers for the ensuing year elected, shall be held as follows:

Sanitary Section.—First Wednesday in March.
Structural Section.—Second Wednesday in March.
Transportation Section.—Fourth Wednesday in February.
Hydraulics Section.—First Wednesday in February.
Surveying & Mapping Section.—Third Wednesday in January

SECTION 2. The officers and other members of the Executive Committee shall be elected at this meeting by written ballot. A Nominating Committee of three members, which shall be elected at a meeting in advance of the Annual Meeting, shall present a list of nominees for officers and other members of the Executive Committee at the Annual Meeting. Additional nominations may be made from the floor.

SECTION 3. The regular meetings of the Section shall be held as follows, unless otherwise authorized by the Executive Committee:

Sanitary Section.—First Wednesday of the months of March, June, October and December.

Structural Section.—Second Wednesday of the months of October to May, inclusive.

Transportation Section.—Third Wednesday in September; fourth Wednesday of the months of November, February and April.

Hydraulics Section.—First Wednesday in February, other meetings first Wednesday in May and November.

Surveying & Mapping Section.—Fourth Wednesday in October, third Wednesday in January and first Wednesday in April.

SECTION 4. Special meetings of the Section shall be held at the call of the Chairman. At special meetings no business shall be transacted, unless announced in the call for the meeting and upon recommendation of the Executive Committee.

SECTION 5. Ten members shall constitute a quorum for the transaction of business.

ARTICLE VI—AMENDMENTS

SECTION 1. Proposed amendments to these By-Laws must be submitted in writing to the Executive Committee, and shall be presented to the Section at a regular meeting, if so decided by vote of the Executive Committee. The Executive Committee shall, however, bring before the Section any proposed amendment at the written request of ten members.

SECTION 2. Announcement of a proposed amendment which is recommended by the Executive Committee or by ten members of the Section shall be given by printing the amendment in the notice of the regular meeting. A two-thirds vote of the members present and voting shall be necessary for the adoption of the amendment.

SECTION 3. All amendments to these By-Laws must receive the approval of the Board of Government of the Boston Society of Civil Engineers before taking effect.

PRIZES AWARDED BY BOSTON SOCIETY OF CIVIL ENGINEERS

As a means of promoting interest among members of the Boston Society of Civil Engineers and members of Student Chapters, a number of prizes have been established which may be awarded annually by the Society to authors of papers of outstanding merit. Other funds are also available for use in various ways for the encouragement of young engineers particularly.

DESMOND FITZGERALD MEDAL AND SCHOLARSHIP

The Desmond FitzGerald Medal, instituted and endowed in 1910 by Desmond FitzGerald, Past President of the Society, is a bronze medal which may be awarded to a member of the Society of any grade, for the best paper judged worthy of special commendation for its merit. With the assent and approval of the donor, the Society has assumed responsibility in perpetuity for the cost of the Desmond FitzGerald Medal. The dies for this medal shall be deposited with the Superintendent of the United States Mint at Philadelphia, in trust exclusively for the above purpose.

The scholarship in memory of Desmond FitzGerald may be awarded by the Board of Government to needy students in civil engineering in accordance with the intent of the donor that the income from the fund be used for charitable and educational purpose. Under the will of Desmond FitzGerald a bequest of $2000 was received in November, 1927.

CLEMENS HERSCHEL AWARD

In 1923, Clemens Herschel, Past President and Honorary Member of the Boston Society of Civil Engineers, presented to the Society a number of autographed copies of his book entitled "Frontinus and the Water Supply of the City of Rome", with the request that the Board of Government award these books as prizes for papers which have been particularly useful and commendable and worthy of grateful acknowledgment. These copies were exhausted in 1941; but the Clemens Herschel fund established in 1931 as a bequest now provides for the award of other books.

SECTION PRIZE AWARDS

The Board of Government of the Boston Society of Civil Engineers, by action on April 12, 1924, amended April 2, 1951, established a prize award to be given annually to a member of each Section* for the best paper presented in each section and published during the year in the JOURNAL, provided that paper is judged worthy of the award. Each such prize consists of a book or books suitably inscribed and of a value not exceeding twenty-five dollars.

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*Sanitary Section
Structural Section
Transportation Section
Hydraulics Section
Surveying and Mapping Section

STUDENT CHAPTER PRIZE AWARD*

By action of the Board of Government on February 7, 1951, a prize similar to that described above for Sections of the Society, was established which may be awarded for the best paper presented by a member of the Student Chapters at a Chapter meeting.

JOHN R. FREEMAN FUND AWARD

In 1925, Mr. John R. Freeman, Past President and Honorary Member of the Boston Society of Civil Engineers, presented to the Society, securities valued at $25,000, the proceeds from which were to be used particularly for the encouragment of young engineers in various ways.

The Freeman Fund is administered and the awards granted by the Freeman Fund Committee of three to five members of the Society recommended by the committee and appointed without time limitation by the Board of Government. Under the terms specified in the deed of gift, the proceeds of the fund are to be used as follows:

"(1) By grants towards expenses for experiments, observations, and compilations towards data that will be useful in engineering and are reported to the Society.

"(2) For underwriting fully or in part some of the loss that may be sustained in the publication of meritorious books, papers, or translations pertaining to hydraulic science and art which might, except for some such assistance, remain mostly inaccessible to the membership of the Society.

"(3) Or such portion of the annual income as the Directors deem proper might be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society during the calendar year, no award being made unless a paper has been presented that is deemed worthy of special recognition, preference being given to the work of students, juniors, or members under forty-five years of age.

"(4)..I suggest that from the income of this fund there be established once in three years a travelling scholarship, open to members under forty-five years of age in any grade, in recognition of achievement, or promise; and for the purpose of aiding in visiting engineering works in the United States or any other part of the world there is good prospect of obtaining information useful to engineers, report of what is found interesting to be made to this Society."

COMMITTEE ON AWARDS

A Committee on Awards shall be appointed by the President annually, not later than June of each year, in the manner set forth in the By-Laws. This Committee shall consist of a Chairman, who shall be a past member of the Board of Government, and one member of each Section, all of whom shall be members of the Society above the grade of Student Member, and none of whom shall be a current member of the Board of Government.

The Secretary of the Society shall act as Secretary to the Committee on Awards, but shall have no vote or voice in its deliberations.

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*Replaces the award established March 10, 1931, which was open only to members of the Northeastern University Section. This Section became a Student Chapter on April 3, 1950, when the formation of student chapters was authorized by the Board of Government.

RULES GOVERNING AWARDS

General. The Committee on Awards shall report its recommendations for each of the awards except the Freeman Fund award to the Board of Government at its January meeting. The awards shall be made by the Board of Government and shall be announced at the Annual Meeting.

Not more than one prize shall be awarded for the same paper.

Desmond FitzGerald Medal. The papers considered for the Desmond FitzGerald Medal shall include all original papers by members of the Society of any grade, presented at meetings of the Society or any of the Sections thereof and published in the JOURNAL of the Society during the year ending with the month of October, provided that no paper shall be eligible which shall have been contributed in whole or in part to any other association or have appeared in print before its publication by the Society. This medal may be awarded annually for a paper judged worthy of special commendation for its merit, one such medal to be awarded, except that in the case of joint authorship of the winning paper, each of the authors who is eligible for the award shall receive a medal. No award will be made if the Board of Government shall decide that none of the papers published during the year is of such a character as to merit the award.

Clemens Herschel Awards. One or more prizes, known as the Clemens Herschel Awards and consisting of books may be awarded for papers which have been particularly useful and commendable. The books shall be suitably inscribed with the name of the recipient, the title of paper and the date of presentation and publication and shall be attested to by the President and Secretary of the Society.

All original papers presented at meetings of the Society or any of its Sections, and published in the JOURNAL, during the year ending with the month of October, shall be eligible for this award without regard to membership of the author in the Society or any of its Sections. No award will be made if the Board of Government shall decide that none of the papers published during the year is of such a character as to merit the award.

Section Prize Awards. In the award of Section Prizes, consideration shall be given to all original papers prepared by members of the respective Sections and which meet with the following additional requirements:

1. Papers shall have been presented at a meeting of the Section and published in the JOURNAL during the year ending with the month of October.
2. No paper shall be eligible which has previously been contributed to any other association, or has appeared in print prior to its presentation to the Section or its publication in the JOURNAL.

One Section Prize shall be awarded annually for the best eligible paper in each Section, provided that paper is judged worthy of special commendation. No award will be made if the Board of Government shall decide that none of the papers published during the year is of such a character as to merit the award.

Each award shall consist of a book or books of a value not exceeding twenty-five dollars, except that in the event of joint authorship of the winning paper, each author shall receive a book or books of value not exceeding fifteen dollars. The books shall be suitably inscribed with the name of the recipient, the title and date of presentation and publication of the paper, and the name of the Section, together with the fact that it was judged the most worthy paper presented in that Section and published during the year. The inscription shall be attested to by the President of the Society and the Chairman of the Section. The Committee on Awards shall select the book or books to be awarded, but shall consult with the recipient as to his particular desires.

Student Chapter Prize Award. Every original paper presented by a member of a Student Chapter and presented by the author at a meeting of said Chapter during the year ending with the month of October shall be eligible for the Student Chapter Prize Award.

The Committee on Awards of the Boston Society of Civil Engineers shall request the faculty advisers of each Student Chapter to submit, at such time as may be required, not more than two papers selected by them from among the papers presented in their Chapter.

The prize shall be awarded annually for that paper which has been judged best of all those submitted to the Committee on Awards, unless no paper presented during that year is deemed worthy.

The award shall consist of a book or books of a value not to exceed fifteen dollars. The books shall be suitably inscribed with the name of the recipient, title of the paper, the date of presentation, and the name of the student chapter. The inscription shall be attested to by the President of the Society and the Chairman of the chapter. The Committee on Awards shall select the book or books, but shall consult with the recipient regarding his particular desires.

The winning paper may be printed in the Journal of the Society at the discretion of the Publication Committee.

December 15, 1950

LIST OF PRIZES AND SCHOLARSHIPS
Awarded by
BOSTON SOCIETY OF CIVIL ENGINEERS

DESMOND FITZGERALD MEDAL

Instituted and endowed in 1910 by Desmond FitzGerald, member and Past President of the Boston Society of Civil Engineers, for an original paper presented by a member of the Society and published during the year, which is adjudged worthy of Special Commendation for its merit.

Awarded at Annual Meeting	*Author and Subject of Paper*
March 20, 1912	—Charles R. Gow. "Methods and Cost of Construction of the Slow Sand Purification Works for the New Springfield, Mass., Water Supply".
March 19, 1913	—Charles T. Main. "The Work, Aim and Conduct of the Engineer".
March 18, 1914	—David A. Hartwell. The Fitchburg, Mass., Intercepting Sewer". Sanitary Section, Feb. 5, 1913.
March 17, 1915	—Joseph R. Worcester. "Boston Foundations". Society, January 28, 1914. January, 1914, JOURNAL.
March 15, 1916	—William S. Johnson. "Ground Water Supplies". Society, Feb. 17, 1915. May 1915, JOURNAL.
March 21, 1917	—Dana M. Wood. "Power Estimates from Stream Flow and Rainfall Data". March 1916, JOURNAL, March, 1916. (not presented).
March 20, 1918	—None.
March 19, 1919	—Stephen DeM. Gage. "The Sanitary Control of Swimming Pools". Sanitary Section, Dec. 5, 1917. June, 1918, JOURNAL.
March 17, 1920	—Edgar S. Dorr & Robert Spurr Weston. "Disposal of Sewage by Treatment with Acid". Society, January 22, 1919; April, 1919, JOURNAL.
March 16, 1921	—Harrison P. Eddy. "Maximum Rates of Precipitation at Boston for Various Frequencies of Occurrence". Feb., 1920, JOURNAL. (not presented).
March 15, 1922	—Harold K. Barrows. "Water Power Development in New England". Society, December 17, 1920. Jan., 1921, JOURNAL.
March 21, 1923	—None.
March 19, 1924	—Arthur T. Safford. "The Amoskeag Manufacturing Company Hydro-Electric Development". Society, January 24, 1923; March, 1923, JOURNAL.
March 25, 1925	—Arthur C. Eaton. "The New England Power Company-Davis Bridge Development". Society, December 17, 1924; January. 1925, JOURNAL.

March 17, 1926—Frank C. Shepherd. "The Preservative Treatment of Ties on the Boston & Maine Railroad". March, 1925, JOURNAL.
March 16, 1927—Harry A. Hageman and Theodore B. Parker. "The Bartlett's Ferry Hydro-Electric Development". Society, February 17, 1926; March, 1926, JOURNAL.
March 21, 1928—Dr. Charles Terzaghi. "Concrete Roads—A Problem in Foundation Engineering". Highway Section, February 23, 1927; May, 1927, JOURNAL.
March 20, 1929—None.
March 19, 1930—James W. Rollins. "Pier Construction for the Mid-Hudson Bridge at Poughkeepsie, N. Y." Society, May 15, 1929; October, 1929, JOURNAL.
March 18, 1931—H. B. Kinnison. "Stream Flow Data—Its Collection and Uses". Society, April 16, 1930; May, 1930, JOURNAL.
March 16, 1932—H. K. Fairbanks. "Wyman Dam and Hydro-Electric Power Development at Bingham, Maine". Society, Nov. 19, 1931; Dec. 1931, JOURNAL.
March 15, 1933—Clarence R. Bliss. "Fifteen Mile Falls Lower Development". Society, May 20, 1932; September, 1932, JOURNAL.
March 21, 1934—Albert E. Kleinert. "The Design and Construction of the French King Bridges on the Mohawk Trail Route across the Connecticut River, Massachusetts". Society, April 18, 1933; June, 1933, JOURNAL.
March 20, 1935—Glennon Gilboy. "Mechanics of Hydraulic-Fill Dams". Society, May 16, 1934; July, 1934, JOURNAL.
March 18, 1936—Arthur Casagrande. "Characteristics of Cohesionless Soils Affecting the Stability of Slopes and Earth Fills". Joint Meeting, Nov. 13, 1935; January, 1936, JOURNAL.
March 17, 1937—Albert Haertlein. "The Design of Statically Indeterminate Trusses". Designers Section, January 8, 1926; April, 1936, JOURNAL.
March 16, 1938—Donald W. Taylor. "Stability of Earth Slopes". Joint Meeting, November 23, 1937; July, 1937, JOURNAL.
March 15, 1939—Arthur D. Weston. "The Charles River Basin". Society, March 16, 1938; October, 1938, JOURNAL.
March 20, 1940—Howard A. Gray. "Enlargement of L. Street Steam-Electric Plant of Boston Edison Company". Society, January 25, 1939; April, 1939, JOURNAL.
March 19, 1941—Harrison P. Eddy, Jr. and Almon L. Fales. "Discussion of Problems of Sewerage & Sewage Disposal in Metropolitan Boston". Joint Meeting, January 24, 1940; April, 1940, JOURNAL.
March 18, 1942—Howard M. Turner and Allen J. Burdoin. "The Flood Hydrographs". Hydraulics Section, May 7, 1941; July, 1941, JOURNAL.
March 17, 1943—John B. Wilbur. "The Smith-Putnam Wind Turbine Project". Society, March 18, 1942; July, 1942, JOURNAL.
March 22, 1944—Ralph W. Horne. "Cranston, Rhode Island, Builds Complete New Sewerage Works for 53,000 People". Joint Meeting, January 27, 1943; April, 1943, JOURNAL.
March 21, 1945—Scott Keith. "Hydraulics of the Park River Conduit, Hartford, Conn.". Hydraulics Section, May 3, 1944; July, 1944, JOURNAL.
March 20, 1946—Prof. Albert G. H. Dietz. "Details of Design with Timber Connectors". Designers Section, October 13, 1943; January, 1945, JOURNAL.

March 19, 1947—No Award.
March 31, 1948—Jack E. McKee, "Loss of Sanitary Sewage Through Storm Water Overflows". Sanitary Section, March 5, 1947; April, 1947 JOURNAL.
March 16, 1949—Thomas R. Camp, "The Merrimac River Valley Sewerage District Project". Society, January 28, 1948; April, 1948 JOURNAL.
March 15, 1950—Edward G. Lee, "The Proposed Redevelopment of the Water Power of the Connecticut River at Wilder, Vermont". January, 1949 JOURNAL.
March 21, 1951—Ralph S. Archibald, "Radioactive Tracers in Flow Tests". Hydraulic Section, November 2, 1949; January, 1950 JOURNAL.

CLEMENS HERSCHEL AWARD

The late Clemens Herschel, a former Past President and Honorary Member of the Society, had assigned to the Society in 1921 a number of autographed copies of his book on "Frontinus and the Water Supply of the City of Rome", with the request that the Board of Government award one or more of these books each year as prizes for papers which have been particularly useful and commendable, and worthy of grateful acknowledgment. In 1931 the Society received a Clemens Herschel bequest amounting to $1000, the income of which is to be used for the same purpose. The prize consists of books, suitably inscribed.

Awarded at
Annual Meeting — *Author and Subject of Paper*

March 15, 1922—Charles R. Gow. "The Responsibility of Organized Labor for the Stagnation in the Building Industry". Society, March 24, 1921; April, 1921, JOURNAL.
March 21, 1923—(a) Arthur T. Safford for his work as Chairman of the Run-Off Committee, the report of which was printed in October, 1922, JOURNAL.
(b) George H. Nye. "What shall be done to secure better City Planning?" Society, May 17, 1922; June, 1922, JOURNAL.
March 19, 1924—(a) John W. Raymond, Jr. "Some Features of Sewer Design". Designers Section, April 12, 1922; January, 1923, JOURNAL.
(b) J. Stuart Crandall. "Floating Dry Dock Design". Designers Section, March 12, 1923; September, 1923, JOURNAL.
March 25, 1925—(a) Almon L. Fales. "Odor Elimination". Sanitary Section, February 6, 1924; April, 1924, JOURNAL.
(b) Charles H. Pierce. "Flood Flows of New England Rivers". Not presented, but printed in October, 1924, JOURNAL.
March 17, 1926—(a) Edward P. Hamilton. "The Development of the Science of Hydraulics". Not presented, but printed in October, 1925, JOURNAL.
(b) Dr. Charles Terzaghi. "Modern Conception Concerning Foundation Engineering". Society, November 18, 1925; Dec., 1925, JOURNAL.
March 16, 1927—(a) Earle B. Phelps, "Chlorination of Water and Sewage". Sanitary Section, February 3, 1926; April, 1926, JOURNAL.
(b) Albert J. Houston. "Some Observations on European Water Power Practice". Society, September 22, 1926; October, 1926, JOURNAL.

(c) D. B. Steinman and W. G. Grove. "Design and Construction of Florianopolis Bridge". Society (Joint), October 20, 1926; November, 1926, JOURNAL.

March 21, 1928—(a) Charles M. Allen. "Water". Annual, March 16, 1927; April, 1927, JOURNAL.

(b) Dr. Geo. H. deTheirry. "Application of Laboratory Research to the Study of Hydraulic Problems". Society, April 28, 1927; January, 1928 JOURNAL.

March 20, 1929—(a) Dr. William Rudolfs. "Sludge Digestion". Sanitary Section, December 5, 1928; January, 1929, JOURNAL.

(b) Edward H. Cameron. "Engineering Features of a Modern Glass Bottle Plant". June, 1928, JOURNAL. (not presented).

March 19, 1930—William F. Uhl. "The Development of the Mongaup River". Society, February 20, 1929; May, 1929, JOURNAL.

March 18, 1931—(a) Edwin A. Dow. "Hydraulic and Mechanical Features of Bellows Falls Hydro-Electric Plant of the N. E. Power System". February 19, 1930 meeting; March, 1930, JOURNAL.

(b) Alexander Gelman. "The Angular Rotation Method for the Analysis of Multiple Span Frames". Designers Section, February 12, 1931; December, 1930, JOURNAL.

[BEQUEST OF $1000 RECEIVED FROM CLEMENS HERSCHEL THIS YEAR]

March 16, 1932—(a) Wm. H. Bassett. "Shrinkage of Concrete in Actual Structures". Designers Section, December 19, 1930; March, 1931, JOURNAL.

(b) J. B. Belknap and C. I. Sterling. "Iron in the Ground-water Supplies of Massachusetts". Sanitary Section, December 2, 1931; January, 1932, JOURNAL.

March 15, 1933—(a) Frank E. Winsor. "The Metropolitan District Water Supply Tunnel from the Ware River to the Wachusett Reservoir". Society, October 19, 1932; November, 1932, JOURNAL.

(b) Arthur Casagrande. "The Structure of Clay and its Importance in Foundation Engineering". Designers Section, January 13, 1932; April, 1932, JOURNAL.

March 21, 1934—Karl R. Kennison. "New Type of Open Flow Nozzle for Measurement of Sewage Flow". Sanitary Section, December 6, 1933; January, 1934, JOURNAL.

March 20, 1935—Leo Jurgenson. "The Application of Theories of Elasticity and Plasticity to Foundation Problems". Designers Section, May 9, 1934; July, 1934, JOURNAL.

March 18, 1936—Richard S. Holmgren. "Sewage Disposal Works, Bristol, R. I." Sanitary Section, October 2, 1935; January, 1936, JOURNAL.

March 17, 1937—No award.

March 16, 1938—Charles M. Noble. "The Factor of Safety in Highway Design". Society, January 27, 1937; April, 1937, JOURNAL.

March 15, 1939—Thaddeus Merriman. "Portland Cement". Society, October 19, 1938; January, 1939, JOURNAL.

March 20, 1940—(a) Otis D. Fellows. "Highway of the Boston Metropolitan District—Their Origin and Evolution". Highway Section, April 26, 1939; July, 1939, JOURNAL.

(b) Charles E. Greene. "Mechanical Equipment for Refuse Incinerators". Sanitary Section, March 1, 1939; July, 1939, JOURNAL.

March 19, 1941*—(a) Miles N. Clair. "Concrete Technology". Society, April 17, 1940; July, 1940, JOURNAL.

(b) Robert D. Chellis. "A Consideration of Pile Driving with Application of Pile Loading Formula". Designers Section, March 13, 1940; January, 1941, JOURNAL.

March 19, 1942—None.

March 17, 1943—Dr. Karl Terzaghi. "Shield Tunnels of the Chicago Subway". Society, May 20, 1942; July, 1942, JOURNAL.

March 22, 1944—William C. White. "Engineering Education, Yesterday, Today and Tomorrow". Society, March 17, 1943; April, 1943, JOURNAL.

March 21, 1945—(a) Howard M. Turner, "Domestic Rates and Consumption". Annual, March 22, 1944; April, 1944, JOURNAL.

(b) Mr. A. C. W. Siecke. "Engineering Highlights of the 'Normandie' Salvage". Society, October 27, 1943; January, 1944, JOURNAL.

March 20, 1946—Prof. Charles O. Baird, Jr. "Photogrammetry". Joint Meeting of Main Society and Highway Section, February 28, 1945; April, 1945, JOURNAL.

March 19, 1947—John B. Wilbur, "The Action of Impulsive Loads on Elastic Structures". Annual Meeting of Society, March 20, 1946; July 1946, JOURNAL.

Oscar S. Bray. "The Mystic Cable Tunnel Design and Construction". Designers Section, December 12, 1945; July, 1946, JOURNAL.

March 31, 1948—Henry L. Kennedy. "Recent Developments in Concrete Durability". Joint Meeting of Designers and Transportation Sections on December 11, 1946; October, 1947, JOURNAL.

March 16, 1949—John B. Babcock, 3rd. "Centennial History of the Boston Society of Civil Engineers, 1848-1948", July, 1948 CENTENNIAL ISSUE OF JOURNAL.

March 15, 1950—Ruth D. Terzaghi. "Concrete Deterioration Due to Carbonic Acid". Society Meeting, February 18, 1948; April, 1949, JOURNAL.

March 21, 1951—Arthur Casagrande. "Notes on Design of Earth Dams". Society, February 15, 1950; October, 1950, JOURNAL.

SECTION PRIZE AWARDS

The Board of Government voted on April 12, 1924, to present a prize for a worthy paper given in each section by a member of that section, "this award to consist of books suitably inscribed".

SANITARY SECTION

Awarded at Annual Meeting — *Author and Subject of Paper*

March 17, 1926—F. William Haley. "Recent Additions to the Sewerage System and Disposal Works of Framingham, Massachusetts". Sanitary Section, March 4, 1925; June, 1925, JOURNAL.

*Last award of copies of "Frontinus and the Water Supply of the City of Rome."

March 16, 1927—Gordon M. Fair. "Sludge Digestion—Reaction and Control". Sanitary Section, December 1, 1926; February, 1926, JOURNAL.
March 20, 1929—Frank A. Marston. "Progress in Sewage Treatment Abroad". Sanitary Section, December 7, 1927; June, 1928, JOURNAL.
March 19, 1930—Robert Spurr Weston. "Some Examples of Pollution of Streams by Industrial Wastes". Sanitary Section, May 6, 1929; June, 1929, JOURNAL.
March 21, 1934—Paul F. Howard. "Sewer Assessment Practice in Massachusetts". Sanitary Section, March 1, 1933; September, 1933, JOURNAL.
March 20, 1935—Arthur L. Shaw. "Newton High Level Sewer". Sanitary Section, March 7, 1934; April, 1934, JOURNAL.
March 18, 1936—Stanley M. Dore. "Design and Progress on Construction of Dams for Quabbin Reservoir". Sanitary Section, May 1, 1936; July, 1935, JOURNAL.
March 17, 1937—Almon L. Fales. "Chemical Precipitation of Sewage and Industrial Wastes". Sanitary Section, April 1, 1936; October, 1936, JOURNAL.
March 16, 1938—Robert Spurr Weston. "The Treatment of Wool Scouring Waste". Sanitary Section, April 7, 1937; July, 1937, JOURNAL.
March 15, 1939—George A. Sampson and Edwin B. Cobb. "Sewage Disposal System at Keene, N. H." Sanitary Section, December 7, 1938; January, 1939, JOURNAL.
March 19, 1941—Thomas R. Camp. "The Filtration for the New M. I. T. Swimming Pool—Design and Operation". Sanitary Section, December 4, 1940; January, 1941, JOURNAL.
March 19, 1947—Allen J. Burdoin. "Gas Engine Power for Sewage Treatment". Sanitary Section, October 3, 1945; January, 1946, JOURNAL.
March 15, 1950—Stuart E. Coburn. "Headaches from Treatment of Combined Idustrial Wastes and Sewage". Sanitary Section, October 6, 1948; January, 1949, JOURNAL.

STRUCTURAL SECTION

Awarded at Annual Meeting — *Author and Subject of Paper*

March 19, 1925—William D. Henderson. "Structural Design Features of a Hydro-Electric Development". Designers Section, February 11, 1925; April, 1925, JOURNAL.
March 17, 1926—Barzillai A. Rich and William W. Bigelow, for their paper. "Stresses in a Composit Member Subjected to Bending and Direct Stress". Designers Section, January 13, 1926; February, 1926, JOURNAL.
March 16, 1927—Ray H. Lindgren. "Design of Details in Timber Structures". Designers Section, April 14, 1926; May, 1926, JOURNAL.
March 21, 1928—Clarence E. Carter. "Repairs to the Folly Hill Reservoir of the Salem Water Supply, Salem, Mass." Designers Section, November 9, 1927; November, 1927, JOURNAL.
March 16, 1932—J. Stuart Crandall. "Piles and Pile Foundations". Designers Section, March 10, 1931; May, 1931, JOURNAL.
March 15, 1933—Howard A. Gray. "Moisture Penetration in Exterior Walls". Designers Section, November 12, 1931; March, 1932, JOURNAL.
March 17, 1937—Herman G. Dresser. "Some Features of Sewer and Culvert Design". Designers Section, March 11, 1936; October, 1936, JOURNAL.

March 16, 1938—John B. Wilbur. "Model Analysis of Structures". Designers Section, December 8, 1937; January 1938, JOURNAL.

March 20, 1940—Dean Peabody, Jr. "Continuous Frame Analysis of Flat Slabs". Designers Section, March 8, 1939; July, 1939, JOURNAL.

March 19, 1941—Richard S. Holmgren. "The Pittsburgh Conservation Reservoir Development of the New Hampshire Water Resources Board". Joint Meeting, February 14, 1940; April, 1940, JOURNAL.

March 18, 1942—Chester J. Ginder and Edwin B. Cobb. "Design of Fabricated Plate Steel Tees, Laterals and Wyes of Large Diameters for the Pressure Aqueduct of the Boston Metropolitan District Water Supply Commission". Designers Section, November 14, 1940: April, 1941, JOURNAL.

March 19, 1947—Henry Brask, "Clamshell Bucket Unloading Towers". Designers Section, February 13, 1946; July, 1946, JOURNAL.

March 31, 1948—Arthur Casagrande. "The Pile Foundations for the New John Hancock Building in Boston". Joint Meeting Structural Section and Main Society, November 20, 1946; October, 1947, JOURNAL.

March 16,1949—Robert J. Hansen. "Long Duration Impulsive Loading of Simple Beams". Structural Section, March 10, 1948; July, 1948, JOURNAL.

March 15, 1950—Charles H. Norris. "Localized Buckling of Structural Members". Structural Section, December 8, 1948; July, 1949, JOURNAL.

March 21, 1951—Dean Peabody, Jr. "The A.B.C.'s of Prestressed Concrete". Structural Section, January 11, 1950; July, 1950, JOURNAL.

HYDRAULICS SECTION

Awarded at Annual Meeting — *Author and Subject of Paper*

March 17, 1943—Karl R. Kennison. "Hydraulics of the New Pressure Aqueduct of the Metropolitan Water District". Hydraulics Section, November 18, 1941; January, 1942, JOURNAL.

March 22, 1944—Thomas R. Camp. "Velocity Gradients and Internal Work in Fluid Motion". Joint Meeting, May 19, 1943; October, 1943, JOURNAL.

March 21, 1945—Edwin B. Cobb. "Flow of Water in Network Piping System". Hydraulics Section, February 2, 1944; October, 1944, JOURNAL.

March 20, 1946—William F. Covil (Posthumously). "A Practical Formula for the Flow of Water in Pipes". Hydraulics Section, November 1, 1944; January, 1945, JOURNAL.

March 31, 1948—Howard M. Turner. "Repairs to Dam, South Barre". Hydraulics Section, May 7, 1947; October, 1947, JOURNAL.

March 16, 1949—George R. Rich. "Basic Hydraulic Transients". Hydraulics Section, February 4, 1948; July, 1948, JOURNAL.

March 15, 1950—Robert T. Colburn. "Design Features of Clark Hill Dam and Power Plant". Hydraulics Section, November 3, 1948; January, 1949, JOURNAL.

March 21, 1951—John G. W. Thomas. "New Controls for Old Canals". Hydraulics Section, February 1, 1950; July, 1950, JOURNAL.

TRANSPORTATION SECTION

Awarded at Annual Meeting	*Author and Subject of Paper*
March 17, 1927—	LeRoy M. Hersum. "Structural Design of Concrete Roads". Highway Section, December 22, 1926; February, 1927, JOURNAL.
March 19, 1930—	Arthur W. Dean. "Massachusetts Highways". Joint Meeting, November 20, 1929; December, 1929, JOURNAL.
March 20, 1946—	Ernest L. Spencer. "Aerial Mapping Equipment". Joint Meeting, Main Society and Transportation Section, February 28, 1945; April, 1945, JOURNAL.
March 31, 1948—	Alexander J. Bone. "Planning the Airport Site". Transportation Section, April 17, 1946; July, 1947, JOURNAL.
March 21, 1951—	John D. M. Luttman-Johnson. "Harbor Engineering with Special Reference to Port Elizabeth Harbor, Union of South Africa". Joint Meeting Main Society and Transportation Section, October 19, 1949; April, 1950, JOURNAL.

SURVEYING & MAPPING SECTION

March 16, 1949—	Charles M. Anderson. "The Engineering Aspects of the Land Court". Joint meeting of Surveying & Mapping Section and Main Society, November 19, 1947; April, 1948, JOURNAL.

NORTHEASTERN UNIVERSITY CHAPTER PRIZE AWARDS

Authorized by vote of Board of Government on March 10, 1931 and awarded for an original paper prepared by a member of the Northeastern University Chapter of Boston Society of Civil Engineers and presented by the author during the year at a regular Engineering Conference meeting. The prize consists of books.

Awarded at Annual Meeting	*Author and Subject of Paper*
March 20, 1940—	Louis G. Reiniger. "How Combat Engineers Span a River". Northeastern University Section, May 5, 1949.
March 19, 1941—	John E. Bamber. "Construction of Spur Railway Track to Camp Edwards". Northeastern University Section, January 10, 1941.
March 18, 1942—	Warren T. Boutelle. "Sewage Treatment at Camp Edwards". Northeastern University Section, May 21, 1941.
March 19, 1947—	Richard W. Newcomb. "Automatic Sprinkler Systems". Northeastern University Section, December 4, 1946.
March 31, 1948—	Leonard B. Loitherstein. "Ship Surveying". Northeastern University Section, December 23, 1947.
March 15, 1950—	Richard D. Raskind. "Land Court Registration Procedure". Northeastern University Section, May 55, 1949.
March 21, 1951—	Harry Palmbaum. "Responsibilities of the Engineering Employer to the Engineering Employee". Northeastern University Student Chapter, March, 1950.

BOSTON SOCIETY OF CIVIL ENGINEERS SCHOLARSHIP IN MEMORY OF DESMOND FITZGERALD

AWARDED TO STUDENTS IN CIVIL ENGINEERING AT NORTHEASTERN UNIVERSITY

In accordance with action by Board of Government on March—, 1931, in establishing the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald, former Past President and Honorary Member of the Society, and in keeping with the intent of the donor that the income from the fund "be used for charitable and educational purposes."

Awarded	*Recipient*	*Awarded*	*Recipient*
April 16, 1931	Raymond E. Edson	May 8, 1940	Daniel W. Miles
April 20, 1932	John L. Freiheit	April 24, 1941	Walter B. Kelley
May 17, 1933	Rolf E. Hamstrom	April 22, 1942	Richard D. Sutliff
April 25, 1934	James N. DeSerio	March 31, 1943	Irving T. Berkland
April 24, 1935	Kenneth F. Knowlton	Nov. 3, 1943	Joseph C. Lawler
April 22, 1936	James L. Dallas	May 11, 1949	Arthur Quaglieri
May 5, 1937	Leslie W. Lenfest	April 26, 1950	Richard D. Raskind
May 4, 1938	Chesley F. Garland	April 16, 1951	David H. Hamilton
May 17, 1939	Norman B. Cleveland		

BOSTON SOCIETY OF CIVIL ENGINEERS SCHOLARSHIP JOHN R. FREEMAN FUND

In 1925 the late John R. Freeman, a Past President and Honorary Member of the Society, made a gift to the Society of securities which was established as the John R. Freeman Fund. The income from this fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses, such as the payment of expenses for experiments and compilations to be reported before the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, reports of which would be presented to the Society.

Recipient	*Period of Scholarship*
Kenneth C. Reynolds	July, 1927 - June, 1929 (2 yrs.)
Samuel Shulits	July, 1928 - June, 1930 (2 yrs.)
Clifford P. Kittredge	July, 1930 - June, 1932 (2 yrs.)
Lawrence L. DeFabritis	July, 1932 - June, 1933 (1 yr.)
Leslie J. Hooper	July, 1934 - June, 1936 (2 yrs.)
Martin A. Mason	July, 1937 - June, 1938 (1 yr.)
Ralph S. Archibald	Oct., 1948 - Sept., 1949 (1 yr.)
Carroll T. Newton	July, 1949 - June, 1950 (1 yr.)

CODE OF ETHICS

Adopted by the Society December 18, 1912

The code is intended to establish certain general principles and rules of action for the members of the Society.

I.

Engineers should encourage sound engineering learning and training in the scientific schools and in actual work.

II.

The success of engineers depends upon their moral character, scientific attainments, industry, integrity and business talent. Aggressive competition which often prevails in ordinary commercial transactions cannot exist among engineers without diminishing their usefuless and lowering the dignity and standing of the profession.

III.

The first duty of engineers is to their clients or employers, who have a right to expect that the portion of their business entrusted to the engineer will receive careful investigation and intelligent treatment, and that any special information derived by the engineer during his employment, will be considered confidential.

IV.

Engineers in their professional relations should be governed by strict rules of honor and courtesy. Their conduct toward each other should be such as to secure mutual confidence and good will.

(*a*) They should take no step with a view to divert to themselves the clients or work of other engineers.

(*b*) If a client should desire to transfer his work to another engineer, it is his privilege to do so, but the engineer in charge should be given notice, with the reason for the same, of such change by the client, and the engineer to whom it is transferred should, before accepting the work, communicate with the engineer in charge, in order that there may be no bad feeling caused through misunderstanding.

(*c*) All communications should be made through a responsible head, unless another has been designated to act for him.

(*d*) Services of an assistant to an engineer should not be secured without first communicating with the principal to ascertain if such action will interfere with his work.

(*e*) An assistant should not accept employment with another engineer without first consulting his superior.

(*f*) A superior should not stand in the way of advancement of a subordinate.

(*g*) The criticism of another's work should be broad and generous. The success of one member brings credit to the profession, and the failure of one, discredit to the whole.

(*h*) The attitude of superiors to subordinates should be that of helpfulness and encouragement.

The attitude of subordinates to superiors should be one of loyalty, free from captious criticism.

The treatment of each by the other should be open and frank.

(*i*) The engineer should be willing to assume his proper share of public work and render such assistance as is possible for the general good of the community.

V.

Consultations should be encouraged in cases of doubt or unusual responsibilty. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair the confidence in the regular engineer, unless it is apparent that he is wholly incompetent.

VI.

With the understanding and consent of their clients, engineers may beforehand place any value on their services deemed proper.

Fees may be made upon a per diem, monthly or yearly basis, or as a fixed sum or upon a percentage basis. In addition a retainer may be charged.

It is desirable that a definite agreement be made in advance as to the fee and the extent of the work to be done, so as to avoid subsequent misunderstanding. The period of time should be designated during which the agreed fees shall apply and beyond which an additional or modified charge may be made.

VII.

Engineers should promptly inform their clients of any business connections, interests or circumstances which might prevent them from giving an unprejudiced opinion.

They should not receive commissions or any remuneration other than their direct charges for services rendered their clients.

In advertising, they should avoid, as far as possible, commercial methods.

VIII.

Engineers acting as experts in legal and other cases in making reports and testifying should not depart from the true statement of results based on sound engineering principles. To base reports or testimony upon theories not so founded and thereby produce erroneous results is highly unprofessional and brings discredit on the profession and upon the engineers guilty of such conduct.

IX.

The attitude of engineers toward contractors should be one of helpful cooperation and tactfulness, combined with just and firm criticism. They should assume a judicial attitude toward both parties to the contract.

X.

As the lines of distinction between the various branches of engineering are becoming less marked, an intimate relation between them should be encouraged.

PROFESSIONAL SERVICES

AND

ADVERTISEMENTS

The advertising pages of the JOURNAL aim to acquaint readers with Professional and Contracting Services and Sources of Various Supplies and Materials. You would find it of advantage to be represented here.

Volume 38 JULY, 1951 Number 3

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROFESSIONAL SERVICES

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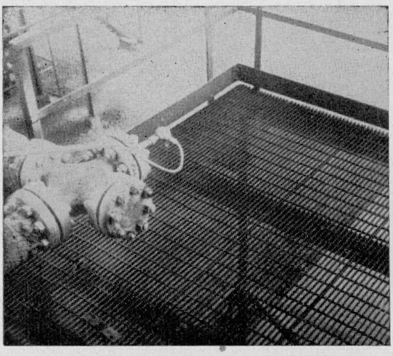

COMMITTEES

1951-1952

NOMINATING COMMITTEE

Past Presidents (Members of the Committee)

Carroll A. Farwell
George A. Sampson
Harvey B. Kinnison
Kenneth F. Knowlton
Herman G. Protze
Ernest L. Spencer
(Term expires March 1952)
Leslie J. Hooper
Byron O. McCoy
Lincoln W. Ryder
(Term expires March 1953)

PROGRAM

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Edward C. Keane
Robert W. Moir
Gardner K. Wood
Frank A. Cundari
Ernest L. Spencer
William E. Stanley
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