DEVELOPMENT OF A LOW-COST TENSION-COMPRESSION EQUIPMENT

WALDEN S. RIO
Dean, College of Engineering, Central Philippine University

Abstract---*The cost of a typical tension-compression equipment is too high so that only a few Civil Engineering (CE) Schools can afford to purchase it. There is, therefore, a need to design and fabricate a low-cost tension compression equipment which CE schools can afford to buy. An applied research project was undertaken to find ways to make such a type of equipment available. The study resulted in the fabrication of a low-cost equipment that could be used for small size tension-compression testing. The results of the testing were not as accurate compared with that of the Universal Testing Machine. Nevertheless, the equipment serves the purpose of letting the students understand the process of testing and provides a solution to the need of Engineering Schools for an affordable tension-compression equipment for their Materials Testing Laboratory.*

INTRODUCTION

In 1985, the Technical Panel for Engineering Education (TPEE) required all engineering schools to comply with the minimum standards for equipment needed in the various engineering laboratories. It was found however that a number of the equipment specified were either useless or not applicable to the practice of civil engineering. An additional problem presented was to identify the people who prepared the minimum equipment standard.

A national conference participated in by representatives from selected civil engineering schools all over the Philippines was held in 1989 to rectify these problems. The purpose of the conference was to list down laboratory exercises that can be undertaken and the corresponding equipment needed for each laboratory exercise.

When the list of laboratory exercises was prepared and the type and number of equipment was specified, the cost of obtaining the equipment was considered. It was found that there is a need to cut down the costs of the equipment. The main reason for this was the fact that majority of the engineering schools could not comply with the minimum number of equipment required by the TPEE Standards. Complying with these standards means spending a sizable amount for the purchase of the equipment. To soften the impact of cost, the number and type of equipment had to be kept to the minimum as required.

In another conference in 1989 the minimum standards for equipment was revised resulting in an increase in the number of equipment. There was therefore a need to introduce a low-cost compression machine. The need was brought about by the fact that testing a reinforcing bar is a very important component in Material Testing.

PROBLEM

The need of undertaking an applied research to design and fabricate low-cost tension-compression equipment had to be answered. The design of the equipment was based on two objectives. First, the cost of fabricating the equipment had to be kept to a minimum. Second, if possible part of the fabricated equipment be made available as a required minimum standard equipment for civil engineering schools. In upgrading it to a tension-compression equipment, the process would be simple and the cost be minimum.

It is an accepted fact that if cost is kept at a minimum, the accuracy of the equipment would not be high. Low accuracy in this case was not much of importance because the developed equipment will be used for instructional purposes only. What is important is for the students to learn the rudiments of material testing using the testing-compression equipment. Hence, the Center for Civil Engineering of the CPU College of Engineering decided to undertake a research on how the equipment would be designed to address the problem presented.

WORK UNDERTAKEN

In order to answer the need for a low-cost Tension-Compression equipment, a survey was undertaken based on the TPEE minimum standards. The purpose of the survey was to take a look at existing minimum standard equipment used in the Material Testing laboratory. A similar survey was also undertaken for equipment used in the Soil Mechanics Laboratory.

The result of the survey in the Material Testing Laboratory showed that the only equipment suited for the purpose was the compression machine. It was found that the cost of a manually operated compression machine of fifty ton capacity would cost around a hundred thousand pesos. A mechanical compression machine would cost more than a hundred fifty thousand pesos. If this equipment is to be converted into a tension compression equipment, the cost would go up to more than two hundred fifty thousand pesos. Since cost was the prime factor in the machine fabrication, it was decided not to convert this equipment.

A detailed investigation of the equipment required for soil mechanics showed that there were two possible equipment that could be used in the development of a tension-compression machine. The first was the unconfined compression equipment which was used to determine the unconfined compressive strength of soil. However, this equipment could only compress up to a load of 500 lbs. Since testing of reinforcing bars requires a higher capacity, this equipment would therefore not be used.

A second compression equipment in the soil mechanics laboratory was then analyzed. It was a compression machine used for determining the California Bearing Ratio. The maximum compressive strength that this equipment could deliver was 5000-10,000 lbs depending on the CBR equipment used. Most equipment were found to be made up of an apparatus consisting of a jack or a set of gears located at the bottom and all sides covered. This type of equipment made its conversion into a tension-compression equipment impossible. It was however discovered that there were California Bearing equipment whose compressive force was delivered by a jack located at the base of the equipment which consisted of a channel. An example of this is shown in Fig. 1.

A design was therefore prepared which could convert the CBR equipment into a tension-compression machine. The basis of the assumption was that with a load of 5,000-10,000 lbs it could test a one fourth inch diameter reinforcing bar for its tensile strength. If the CBR equipment is converted into a tension-compressive equipment, the cost of doing it would be minimal. The reason for the cost being minimum was that only a very small amount was needed for the conversion process.

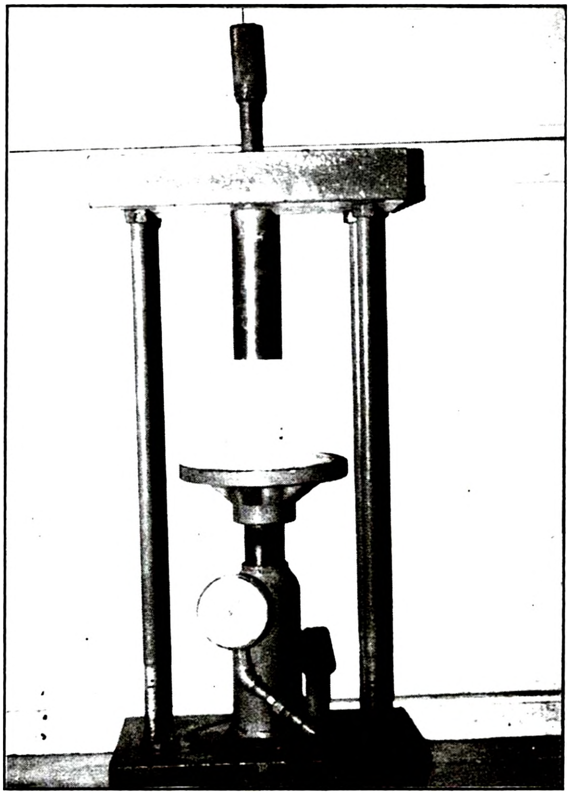

Figure 1. CBR Setup

The process consisted of boring two holes on the top and bottom channels of the equipment. Both holes were equidistant from the center and did not affect the compressive forces. In order to convert the CBR into a tension-compressive machine, there was a need to transfer the base channel of the equipment to the top. In turn, the top channel of the CBR equipment was transferred into the bottom part and acted as the base of the equipment. In doing this, no change was done on the equipment except for the boring of the two holes into the channel.

The equipment however could not yet function as a tension-compression machine. There was a need to provide additional parts to be placed in the equipment. The first part added was a yoke placed on top of the jack. At the bottom of the channel in which the jack was located, another yoke was attached. Both ends of the lower yoke were attached to the ends of the upper yoke within detachable steel bars. All these yokes were attached to the upper channel.

In the lower yoke attached to the upper channel, a hole was bored at its center and a shaft going down was attached and bolted to its bottom. At the bottom channel a shaft was attached to the channel with a bolt. The shaft was located at the center of the channel. This is shown in Fig 2.

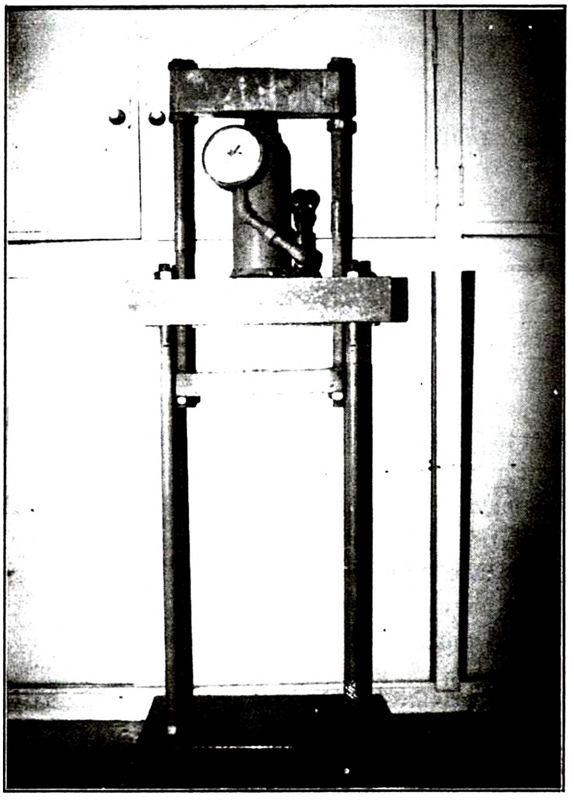

Figure 2. Conversion of CBR Equipment

Both shaft ends have inside threads. The purpose of the threads was to attach bars to be tested for tension to both shafts. When the bars were properly placed a steel bar was attached for the tension and the testing of the steel bar was ready. This is illustrated in Fig. 3.

The jack was then closed and a force exerted. This force was transferred to the top yoke. In turn, the force was conveyed to the lower yoke of the upper shaft in a vertical upward movement. Since the bottom part of the steel bar was attached to the shaft which in turn was attached to the base, it was therefore subjected to a tensile force. In order for failure to take place at the right point, the tensile load was applied at a very slow rate. As the tension bar elongated, a mechanical strain gauge recorded

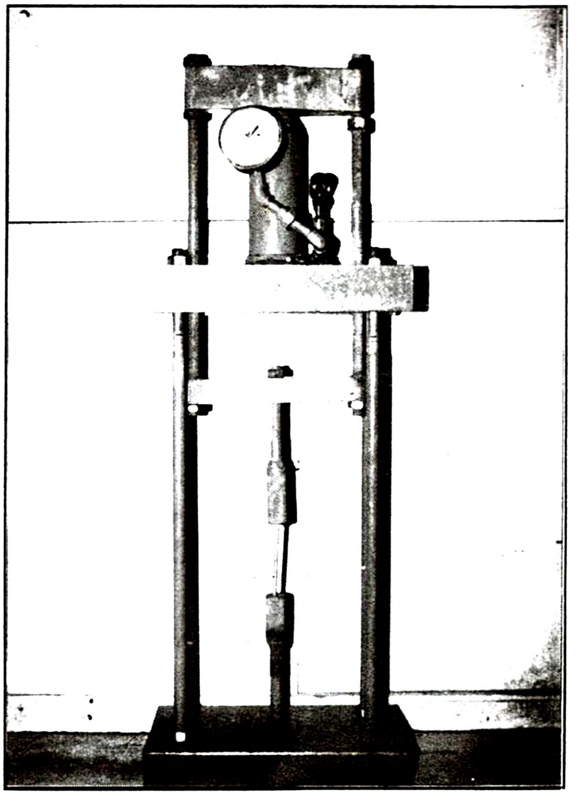

Figure 3. Tension-Compression Machine

the deformation taking place. When it was almost time for the steel bar to break, the mechanical strain gauge was removed in order to prevent its being damaged. What was important was to determine the yield strength of the steel bar.

Two important stresses have been recorded based on the tension test. The first was the unit strain which was based on the results of the reading of the mechanical strain gauge which received the strain. This value divided by the total length of the sample is the given value of the unit strain. The second important data that was recorded was the unit stress which was equal to the force delivered by the jack divided by the area of the reinforcing bar.

The tension-compression machine could also be used for several other tests. Among these are: as a compression machine, it was used to test the flexture strength of wood and concrete. It can also be used to determine the shear stress of wood, compression strength of wood and tensile strength of wood when used as a tension equipment. The five different tests which could be done by this machine made it so versatile inspite of the low cost of fabricating the equipment including all the attachments.

The results of the various tests undertaken by the tension-compression equipment were analyzed and evaluated. It was found that by compression, the results of the various values of failure compared to when tested in a UTM was not very large. With the above assumption, it was recommended that this equipment could be used in any CE material testing laboratory in need of this type of equipment.

The need for a low-cost tension-compression machine was now answered. It could not only be used as a CBR equipment but also for a lot of other tests as previously mentioned in this paper. The results show that the effort in developing this equipment was worthwhile since it made available for use an equipment which would do a tension test at a very low cost.

CONCLUSION

An analysis of the performance of the tension-compression machine that was developed in this research work showed several advantages and are the following:

a. The cost of fabricating the tension-compression equipment was minimal.
b. The cost of converting the equipment from a CBR compression equipment to a tension-compression was minimal.
c. Several other material testing procedures could be done by this equipment which will benefit the students using the laboratory.
d. The process of converting the equipment into a tension-setup from compression takes a very short time.
e. Some of the tests that could be done by the equipment exceeded what is required by the TPEE minimum standards.

Although the advantages of using the equipment are substantial, it should however be mentioned that it also had defects and among the important ones are the following:

a. The rate of applying the load could not be easily controlled since it was done manually.
b. Tension test was possible for minimum diameter bars only and both ends of the bar had to be threaded in order that it can be attached to both shafts.
c. The accuracy of the results was not as high as the results of the mechanical tension-compression.
d. The stress-strain curve cannot be plotted by the machine automatically.

RECOMMENDATIONS FOR FUTURE WORK

The work undertaken to develop a low-cost compression-tension machine has been completed. There is, however, a need to continue the development of a much better tension-compression machine. The Civil Engineering laboratories need a low-cost mechanized tension-compression machine. One of the advantages of a mechanized tension-compression machine is that the rate of loading can be regulated while doing the test. The advantage of a slow rate of loading is that the location of failure point is accurate. This will in turn give the desired results which a hand operated tension-compression equipment cannot easily do. If this problem can be solved in the future, it will help upgrade the material testing equipment of any civil engineering school.

Any future work in this direction will therefore be helpful. Two objectives that should be accomplished are: the need to increase the accuracy of the developed equipment and to design a tension-compression equipment that can deliver a tensile load of 100,000 lbs.

REFERENCES

The TPEAE Report - 1986.

Revised Policies and Standards for Engineering Education- DECS Order No. 102, 1989.

Engineering Education in the Philippines - Dr. Francisco Viray, 1993.