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ENROLLMENT AND INCOMES IN CIVIL ENGINEERING CAN BE INCREASED

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Enrollment and Incomes in Civil Engineering can be Increased*

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Civil engineering has dropped to third place in enrollment and incomes. What can we educators do about it?

This paper attempts to look forward from fifty years of experience and to resolve the paradox of enrollment and income falling relatively while more graduates at higher incomes are needed for the technical and management staffs of American industry, especially for its largest industry, construction. The paper iterates briefly and brings up to date a paper and bibliography on a similar topic presented a year ago and published in condensed form in the *Civil Engineering Bulletin* of ASEE for March 1955. It should be useful in applying the findings of the ASEE Committee on Evaluation.

The Crisis

We, at the height, are ready to decline.
There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.
On such a full sea are we now afloat,
And we must take the current when it serves
Or lose our ventures.

From Shakespeare's *Julius Caesar*

A critical shortage of engineers threatens national welfare. Secretary of the Air Force Quarles has recently written that this shortage of engineering and science graduates is a major peril to the United States, in contrast to the much greater number educated in these fields in Russia. Lt. Gen. Groves (retired), atomic expert, questions "How long can we expect to survive if our present annual production of engineers is only 20,000 and not increasing, while Russia's is 54,000 and constantly increasing?" We must note further that Russia also greatly surpasses us in training sub-professionals and in emphasizing mathematics and science at both higher and lower levels. Both Churchill and Eisenhower indicate that our present technical superiority may be short-lived.

As an example of great importance to civil engineering, the national Associated General Contractors of America, the national Highway Research Board, and many others warn that a shortage of civil engineers threatens construction and this in turn menaces all industry and national defense.

Construction and Education Are Essential for Full Employment

Most business commentators credit construction as a bulwark of present prosperity. Furthermore, prosperity for the future is even more dependent on construction and education. Construction will provide immediate jobs, and education will keep part of the labor surplus in school. For the more distant future, they together will provide the research, plant, equipment and personnel housing, automation, technical and management personnel, know-how, and jobs needed to absorb the two million new workers that

* Presented at the Annual Meeting of ASEE, Civil Engineering Division, Penn State University, June 23, 1955.

will be added each year to our present working force of sixty-five million persons. Construction needs more civil engineers; then it will provide more new industrial facilities that will employ more workers. Consumer and war spending does not create new plants although it does create a demand for them.

This constantly increasing supply of jobs is essential for increased living standards, for strengthened national defense, for winning political elections, and for the very life of a successful democracy. We are committed to it politically. No party can win an election without full employment. The alternative to a large construction program is a change of political administrations, unbalanced budgets, increased debt, inflation, and the ruinous effects of unsound money especially on white collar, old age, and low income groups. Construction can be largely self-liquidating and will support much education, both directly and indirectly.

Construction

For several years expenditure for construction, replacement, and maintenance of our industrial and governmental plants has exceeded $50 billion annually, thus becoming America's largest industry. The 1954 expenditures of $52 billion are increasing to over $56 billion in 1955 and should continue at rising levels. The overall construction program will comprise 15% of the total national production and will employ nearly 10 million workers. The highway program alone may spend $100 billion over the next 10 years.

Investigation by the national Associated General Contractors has indicated that adequate material, labor, and equipment will be forthcoming, but that the bottleneck in construction is the increasing shortage of construction engineers. The national Highway Research Board estimates that most of a year's entire U. S. output of civil engineering graduates may be needed soon for highways alone, instead of the few per cent annually entering that field.

High School Preparation

So that their students may be prepared for engineering, high schools must emphasize mathematics and science, especially mathematics, since such studies in high schools have dropped to an all-time low. Of a recent rural high school group of 250 boys and girls, a very satisfactory 36 per cent, all men, were interested in engineering, but only 5 per cent had the required 3 units of mathematics, 7 per cent had 2 units, and the balance 1 unit or less. This fatal obstacle must be overcome. More high school graduates of both sexes must be attracted to the large and well-paid fields of construction and management.

Civil Engineering Education

The engineering colleges must double their output of civil engineering graduates, of whom about a third enter the armed forces and another third accept minor management positions. Corresponding attention must be given to graduate study and research in the construction field. Such an educational program will be designed to give better, quicker, and less expensive construction; to reverse the increasing construction costs that now are a burden on every business and every individual; and to facilitate national defense.

There now exists the greatest potential demand ever known for civil engineers. Civil engineering technology is neither new nor spectacular, is not advancing as rapidly as that of other engineering, and cannot compete on these bases. Its lack of appeal to young men and women must be corrected. Considering all departments of engineering, civil now suffers slightly lower median incomes, due largely to low governmental salaries. By fortunate contrast, contracting and professional management pay the highest. Remedial action is mandatory. How little is, or can be, done by engineering societies toward increased incomes is explained in an editorial in *Engineering News-Record* for March 17, 1955.

Construction and "Professional" Management

How can we regain our lost prestige? Minor alleviation will not revive a declining phase of education, as witness the dead languages. We must maintain our proved and established disciplines but realize today's need for engineered construction and for professional management, then realistically prepare more students to meet modern critical industrial and defense demands while assuring increased incomes for them. The actual curricular change needed is slight and is far within the 10 per cent allowed by the ASEE Committee on Evaluation. Massachusetts Institute of Technology already has a major option in Construction and Management. We at the University of Missouri now use only six credits or four per cent of the curriculum for Construction and Professional Management, and other engineering colleges have similar programs. It is not advocated that descriptive details of construction and management be taught in college nor is it contended that the four-year graduate entering construction and management is fully educated. He, like the researcher or designer, must continue to learn although he will undertake graduate study less often.

However, as anything we want students to consider seriously, the importance of construction and professional management must be impressed upon them in many ways, although not glamourized. For example, they should know that already the 1950 census classifies half of professional civil engineers in construction, that management is now a profession requiring an educated professional viewpoint which is easily included in engineering curricula, that getting along with people is essential for both construction and management, and that even the technical engineer must know and conform to the aims of construction and management. Construction and management situations should be emphasized more in most of our courses. In line with modern trends and developments, we should publicize such terms as *engineer-contractor, engineered construction, construction management,* and *professional management.*

Construction (including suppliers of materials, equipment, and the like) provides mainly management openings. In addition, there are excellent positions for our men in the professional management of government such as in city managership and in highways; and in industry other than construction such as the railway, aircraft, oil, steel, chemical, and public utility fields. Fortunately, the civil engineer who is qualified in construction management can either remain in construction profitably or change over to upper level industrial management.

Because of obsolescence, new products, bombing hazards, decentralization, and the like, the construction and expansion program today is often as important to an organization as its operations. Thus former engineer-managers of construction now are becoming even more necessary and valuable as top professional managers for industry than in the past, and this has always been the civil engineer's main approach to top management.

Many of our graduates will find satisfying careers intermediately between management and technology as staff officers, consulting engineers, marketing specialists, financial advisers, managers for associations, and the like.

The Rise and Fall of Engineers as Managers

Around the turn of the century, managers were strong entrepreneurs and lucky gamblers (rarely engineers) who built their own businesses, and often lost them. The few larger corporations were often in receiverships.

Then followed a period of larger corporations managed mainly by lawyers, marketing men, financiers, and engineers who seldom had sought management positions; more often they were impressed into management. Failures still predominated the scene.

Since the great depression the need has become recognized for professional managers (most frequently engineers), not those rugged individualists of the early period nor the capable specialists of the middle period, but men trained from the beginning to become conservative professional managers (almost trustees) for unbelievably large and stable organizations where failure must be prevented. They are skilled in government, tax law, mergers, finance, public relations, and human relations; with their eye on management at intermediate and high levels, including board policy determination and above management details such as are usually taught in colleges. This group must start early, for example in college, to partly direct their attention toward professional management rather than exclusively toward technical specialization and science.

Civil engineers can better be pointed in this direction while in college than can other kinds of engineers who are becoming increasingly swamped under specializations in science, technology, and gadgets. Art, rather than science, characterizes both civil engineering and management. Even before this trend toward science the larger corporations favored civil engineers as managers. For example, half of the presidents of our larger railroads were civil engineers, while no other engineers occupied presidencies even though there were nearly as many of them on railroads as there were of civil engineers. And civil engineer executives predominated in the growing steel, oil, and other large industries. Consulting engineer-management firms frequently were staffed with a considerable proportion of civil engineers.

In November, 1952, a study in *Fortune* magazine showed nearly 45% of America's top industrial management to have engineering backgrounds. But it also showed that this percentage was greatly decreased (to 28%) for those under 50 years of age; in other words, that the proportion of engineers in top management had passed the peak and that younger engineers already were losing out to non-engineers (often to graduates in business administration) who more aggressively prepared and sold themselves for management.

Now civil engineers are losing their hardwon leadership and new examples of missing their management opportunities occur constantly. For almost the first time in history, a baggage master instead of a civil engineer has been made president of the Pennsylvania Railroad; a board chairman and civil engineer of Standard Oil of New Jersey was succeeded by a geologist; civil engineer president of A. T. & T. was succeeded by an electrical engineer; a cost-accountant has become board chairman of Ford Motors although in the past civil engineers like the late L. F. Loree, not accountants, mounted to top management through cost controls; a lawyer-financier has succeeded a civil engineer as board chairman of U. S. Steel; and a civil engineer president of the great Canadian Pacific Railway has been succeeded by a mechanical engineer with some interest in management.

There are those who will say that we should train good engineers and some will become managers, but nowadays the odds are against them and the possibility in this direction is rapidly diminishing. Civil engineers in the past were drafted into management, sometimes unwillingly, and they seldom prepared for or sought it. But conditions have changed. If we educators do not point out this management opportunity and give introductory study leading to management, our few graduates will largely remain technicians or modestly paid professional engineers and they will not be given management responsibilities and training by their employers.

Fortunately civil engineers now are needed to manage construction and can rise again in management by stressing education for construction and professional management. By the same process, some will develop the art of "how to be happy, though managed."

A Program

The present low ebb in civil engineering education has been developing over the years and will not remedy itself without strenuous effort on our part. Let us retain our established and proven disciplines but point them a little more toward construction and professional management, leaving additional basic science and specialization for graduate study. The holder of a bachelor's degree only seldom will become an outstanding professional designer, researcher, or educator and he should not be misled into thinking that he will.

As our management-trained civils take over more management positions that were being filled by others, those civil engineers remaining in design, development, research, and teaching will enroll for more graduate study, will become truly professional, and will be better paid. Our enrollment and prestige will increase; our graduates will think better of us; and from influential management positions they will more actively support us and our departments financially, by sending us students and employing them, and in other ways.

The national Associated General Contractors last summer established an Educational Committee that is prepared to increase actively its present cooperation with us. Chairman D. W. Winkelman of that Committee, also member of the American Society of Civil Engineers and president of the D. W. Winkelman Company which has just completed part of the Ohio turnpike, is author of an important article entitled "Construction Management Needs the Civil Engineer" in *Civil Engineering* for February 1955 in which he states, ". . . My purpose here is to stress what I believe is the equal necessity for thoroughly competent men to engage in the management of construction firms which actually build those facilities that are vital to the progress of the country. . . . Management needs the civil engineer with construction experience and managerial and executive ability."

Conclusion

In conclusion may I plead that civil engineering educators collaborate in a comprehensive and inter-related five-fold campaign before it is too late, including:

1. More mathematics in high schools, starting in junior high and involving close cooperation with high schools.
2. More effective solicitation of high school students, assisted by the Associated General Contractors, highway departments, and industry.
3. At least one course at the senior-graduate level in *Construction* (management, not construction details) and one course in *The Engineer's Relation to Professional Management* (principles, not details), perhaps including introductions to law and engineering economy.
4. Emphasis on these areas in our classes and public relations.
5. Sufficient research, graduate study, and public relations to assure getting our share of the college student body.

For the want of a nail the shoe was lost,
For the want a of shoe the horse was lost,
For the want of a horse the rider was lost,
For the want of a rider the battle was lost,
For the want of a battle the kingdom was lost,
And all for want of a horseshoe-nail.

From Benjamin Franklin's *Poor Richard*

For the want of a realistic shift in emphasis, shall civil engineering accept a permanent third place in engineering? All five points of the campaign must be adopted together; they will not be effective separately.

PUBLICATIONS OF THE ENGINEERING REPRINT SERIES

Copies of the complete list of publications may be secured from the Director of the Engineering Experiment Station, University of Missouri

Reprint No.

11. Ternary System Ethyl Alcohol--n--Heptane-Water at 30°C, by Joseph L. Schweppe, Research Engineer, C. F. Braun and Co. and James R. Lorah, Associate Professor Chemical Engineering. Reprinted from Industrial and Engineering Chemistry, Vol. 26, p. 2391, November 1954.
    The Rectifying Property of Polarized Barium Titanate, by Donald L. Waidelich, Associate Director, Engineering Experiment Station and Professor of Electrical Engineering. Reprinted from Journal of the Acoustical Society of America, Vol. 25, p. 796, July 1953.

12. Chip Breakers Studies 1, Design and Performance of Ground Chip Breakers, Erik K. Henriksen, Associate Professor of Mechanical Engineering

    Balanced Design Will Fit the Chip Breaker to the Job, from American Machinist, April 26, 1954, pp. 117-124, Special Report No. 360.

    How to Select Chip Breakers I, II, III, from American Machinist, May 10, 1954, pp. 179, 181, 183, Reference Book Sheets.

    Chip Breaking-A Study of Three-Dimensional Chip Flow, from page No. 53-5-9, presented at the A.S.M.E. Spring Meeting, Columbus, Ohio, April 28-30, 1953.

    Economical Chip Breakers for Machining Steel, from Technical Aids to Small Business, May 1954, pp. 1-8.

13. The Design of Sampled-Data Feedback Systems by Gladwyn V. Lago, Associate Professor of Electrical Engineering and John G. Truxal, Polytechnic Institute of Brooklyn. Reprinted from Transactions of the A.I.E.E., Vol. 73, Part 2, p. 247, 1954.

14. Selection of Personnel by George W. Elliott, Assistant Professor of Mechanical Engineering. Reprinted from the 1954 Transcript of the Midwest Feed Production School.

15. Lightweight Aggregates for Structural Concrete by Adrain Pauw, Associate Professor of Civil Engineering. Reprinted from the Proceedings of the A.S.C.E., Vol. 81, Separate No. 584, January 1955.

16. Coating Thickness Measurements Using Pulsed Eddy Currents by Donald L. Waidelich, Associate Director, Engineering Experiment Station. Reprinted from the Proceedings of the National Electronics Conference, Vol. 10, February 1955.

17. Additions to Sample-Data Theory by G. V. Lago, Associate Professor of Electrical Engineering. Reprinted from the Proceedings of the National Electronics Conference, Vol. 10, February 1955.

18. Additions to Z-Transformation Theory for Sample-Data Systems by Gladwyn V. Lago, Associate Professor of Electrical Engineering. Reprinted from Transactions of the American Institute of Electrical Engineers, Vol. 74, January, 1955.

19. Tension Control for High Strength Structural Bolts by Adrian Pauw, Professor of Civil Engineering and Leonard L. Howard, Lakeland Engineering Associates, Inc., with a discussion on the Turn-of-the-Nut Method by E. J. Ruble, Association of American Railroads. Reprinted from the Proceedings of the American Institute of Steel Construction, National Engineering Conference, April 18-19, 1955.

20. Autotransformer Betters Motor Phase Conversion by Joseph C. Hogan, Associate Professor of Electrical Engineering. Reprinted from Electrical World, Vol. 144, p. 120, October 17, 1955.

21. Sequence Summation Factors by Adrain Pauw, Professor of Civil Engineering. Reprinted from the Proceedings of the American Society of Civil Engineers. Vol. 81, Paper No. 763, August, 1955.

22. Pulsed Eddy Currents Gage Plating Thickness by Donald L. Waidelich, Associate Director, Engineering Experiment Station. Reprinted from Electronics, Vol. 28, p. 146, November, 1955.

23. Relay Protection for Lines Being Sleet-Melted by the Short-Circuit Method by J. C. Hogan, Associate Professor of Electrical Engineering and C. G. Pebler, Commonwealth Associates, Inc. Reprinted from Transactions of the American Institute of Electrical Engineers, Vol. 74, December, 1955.

24. Supplemental Irrigation....Careful Planning is Essential by Harry Rubey, Professor of Civil Engineering. Reprinted from What's New in Crops and Soils, Vol. 7, August-September, 1955.

25. Analysis of Single-Phase-to-Three-Phase Static Phase Converters by J. C. Hogan, Associate Professor of Electrical Engineering. Reprinted from Transactions of the American Institute of Electrical Engineers, Vol. 74, p. 403, January, 1956.

26. Enrollment and Incomes in Civil Engineering can be Increased by Harry Rubey, Professor of Civil Engineering. Reprinted from Journal of Engineering Education, Vol. 46, p. 236, November, 1955.

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