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CIVIL ENGINEERING: YESTERDAY, TODAY AND TOMORROW

BY

ROBERT F. LEGGET

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Civil Engineering: Yesterday, Today and Tomorrow

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An address delivered at the official opening of the Galbraith Building, University of Toronto, March 7, 1961.

The dedication of a new building at a university for its intended use is always a memorable, and indeed often a moving occasion. Thoughts turn backwards to those who have gone before and the work they did with limited facilities, now being so splendidly supplemented. The new building itself is to be admired, praised and critically examined, with full realization of all the effort that has gone into its conception, planning and construction and its equipment for its intended purpose. Above all such impressions, however, is the ever-present challenge of the use to which the building is to be put, thoughts of the successive groups of eager young students who will tramp its corridors, learn in its classrooms and experiment in its laboratories as they follow their university training, in preparation for taking their places in the profession or calling which they have elected to follow.

This kaleidoscope of impressions must be in the minds of all of us today, as we gather for the formal opening of the fine additon to the physical plant that houses the real University of Toronto represented by the Galbraith Building. We think of the forecasts of the exploding numbers of young people who will be attending this, and indeed all universities in the next decade. We know that in its halls there will be trained some who will achieve fame as engineers, some who will use their engineering training as background for distinctive service in other walks of life, and many who will serve faithfully and well in the varied ordinary callings of the engineer

across the length and breadth of this land, all contributing to the development of Canada, aided by what they have learned within the new building.

We can and do admire the building itself. Even the preparation of its site involved a civil engineering operation of note, the bodily removal "up the street" of the building of another Faculty. We can appreciate the truly functional design of the building, fortunately conventional in appearance but incorporating all that is best in modern architectural design. In one respect, at least, it is unique. In its layout and detailed design, a new approach was made to the logical integration of its several parts, utilizing a process called by the rather ugly term "Modular Co-ordination", a name that almost disguises the application of common sense to the dimensioning of building elements and building plans. So far as is known, it is the largest building in Canada yet to have been designed according to modular principles. The full story of this pioneer adventure in design will be told elsewhere. Suffice to say here that the Galbraith building has already achieved fame beyond the borders of Canada amongst those who regard modular design as one of the most significant current developments in architectural practice.

And what of the past? It is significant that it is exactly one hundred years since the first Toronto graduate in engineering, C. F. G. Robertson, received his degree from University College. This was in those formative years when the first fledgling attempts were being made to introduce professional training for engineers in Canada, a movement in which this University was a pioneer. What is perhaps even more significant is that it is almost exactly fifty years since the then Dean of the Faculty of Applied Science and Engineering made a stirring and urgent plea for a new building to replace the old Engineering Building, which we still see in active use today. It is true that in the intervening years the Department of Civil Engineering has been accommodated in the prison-like structure for so long known as the "Electrical Building". Today, however, no such invidious distinction is made, for the fine new structure is honoured for all time by the name that it bears, the name of John Galbraith.

"Who was Galbraith?" is a question that will be asked in its halls many times down through the years by students of inquiring mind who may have stopped to look at the rather austere appearance of the stocky man with the sideburns in the splendid portrait by Forster. "Who was Galbraith?" is a question, therefore, that all members of staff who serve in the new building should be able to answer as they maintain and develop the long tradition of "S.P.S.", "the School", or the Faculty of Applied Science and Engineering as it now has been for well over fifty years. Most fortunately, all of us have been aided in our appreciation of this very great man by the fine memoir so affectionately written by one of Dean Galbraith's successors, our own well beloved "C. R." Young. Every graduate of this Faculty should be the proud possessor of a copy of his slim volume* which has recorded for all time the main events in the early history of engineering at this University and, of perhaps greater importance, something of the character of the chief participants in this pioneer development. All who come to speak of John Galbraith will be in Dr. Young's debt, as I so surely am today.

A practising engineer for ten years, first (and only) Principal of the School of Practical Science, and then the first Dean of the Faculty of Applied Science and Engineering, Galbraith was in every sense the founder of engineering education at this University. That he was also an eminent civil engineer will not surprise us here today. What continues to surprise even those of us who have heard it from senior friends who were once his younger colleagues is the scope of his activities and the breadth of his vision. At one time personally responsible for *all* the engineering instruction in the School, as well as for its administration, his weekly lecture load of fourteen courses which occupied him for seven hours of every day seems to belong to another world. But he took this in his stride, some of his incidental concerns being the need for increased accommodation for the steadily mounting numbers of students, and complaints at the inadequacies of the building that so many of us know as the "Little Red School

*Young, C. R., "Early Engineering Education at Toronto, 1851–1919". University of Toronto Press, 150 pp., 1958.

House" still standing and still serving today, despite all the abuse, oral and physical to which it has been subjected.

Can you not imagine the spirit of Johnnie Galbraith (as he was affectionately known) coming over from his old office in the "School" to wander around the building to be dedicated today, lost in amazement at all he saw? Can you not see him looking unbelievably at the air conditioning equipment that so distinguishes the building, contrasting this with his oft repeated requests for any ventilation arrangements at all for the old basement chemical laboratories, the smell in which defied description. He would look enviously at even such mundane details as the equipment in toilets, recalling his abortive efforts to get fittings that worked properly for the building that was the cradle of so much of the great civil engineering of this land. He would probably find the new heating plant for the University the most difficult of all to believe, and he would recall the protest he had once to send to "Queen's Park" about the man they had sent to him as a fireman for the old School heating system, who "knew nothing about steam boilers, didn't know what a steam gauge was, had never burned coal". He would remember days when the inadequate heating system failed, allowing water pipes and glassware to freeze and burst. And if he were to walk in to this great room and face us now, can you not hear him saying, with that characteristic occasional lisp of his, "What is civil engineering coming to?" And that, I submit, is a very good question to which we may address ourselves as we participate in the start of the service that the Galbraith building is to give to civil engineering of the future, first taking stock of the past, reviewing the status of civil engineering today, before finally glancing ahead into the unknown of the future.

Come with me, then, in your imaginations across the Atlantic, on to Plymouth Hoe in south western England. There on the evening of 16 October 1759—almost exactly two hundred years ago—we could have seen a stolid Yorkshireman viewing through his telescope the empty horizon. Even his weather-beaten face must have lit up with a smile when he finally saw what he had been expecting, a faint pinpoint of light coming from the twenty-four six-pound tallow candles

that provided the light for the new Eddystone Lighthouse, now lit for the first time by three keepers in the lantern, seventy feet above the rocks below. The man on the Hoe was John Smeaton, the first civil engineer, prevented by bad seas from being at the Light itself. And what makes the incident so memorable for us today is not only the fact that Smeaton's Eddystone Lighthouse was in many ways the first modern civil engineering structure but also the fact that on the very next day, 17 October 1759, London "went mad" as the news was received of the great battle at Quebec on the Heights of Abraham. It is quite a striking coincidence that the history of the Canada of today is exactly contemporaneous with the history of modern civil engineering.

John Smeaton was a most remarkable man but his genius has been rather overshadowed by the commanding figure of Thomas Telford who carried out his great works fifty years later. Telford will always be remembered as the founder-president of the Institution of Civil Engineers, today generally acknowledged as the leading engineering society of the world. But fifty years before the Institution was founded, Smeaton had taken the first steps towards establishing an organisation that still exists as the Smeatonian Society, today a private and exclusive dining club, now in its 180th year. The fact that this society is so little known is entirely in keeping with John Smeaton's own modesty. His name did not appear anywhere on the Eddystone Lighthouse, his masterpiece. He refused to agree to this, instructing that two inscriptions only should be carved into its stone walls—in the storeroom "Except the Lord build the house, they labour in vain that build it", and above the lantern door "24th Aug. 1759. Laus Deo".

The epitome of the true master builder, Smeaton can still serve as an inspiration to all civil engineers; his portrait will have, I am sure, a prominent place in Galbraith building. His code of labour management for the Eddystone work reads in many respects like a very enlightened modern labour-relations agreement. The way in which he studied the site, despite the difficulties of tides and storms, his reasons for selecting the "moorstone" as his material of construction, his ingenious and original design of interlocking dovetailed stones to form the

foundation of the tower, and above all his library research and subsequent experimentation on the proper type of "cement" to use for his mortar based on Roman practice, in all these ways Smeaton provided an example that can still be followed with advantage. Well might it be said about him:

> "Smeaton is the greatest philosopher in our profession this country has yet produced . . . he was an incessant experimenter. His mind was as clear as crystal . . . when young men asked me . . . what they should read I invariably say 'Go to Smeaton's philosophical papers; read them, master them thoroughly, and nothing will be of greater service to you.' Smeaton was indeed a very great man."

So also was Robert Stephenson, the writer of these words in 1858, almost one hundred years later.

This first century of modern civil engineering saw the foundations well laid for the practice of the profession as we know it today; the great age of canal building came and started to recede as railway building began its meteoric rise; the first great roads were built and the engineer's responsibilities for urban development were already recognised. This same century saw Canada progress from its first formative days to the eve of its re-birth as a nation in its own right when it became the Dominion of Canada in 1867. In making this progress, the country had been opened up and developed in a physical sense by civil engineers, their work reaching a milestone just a century ago when H.R.H. the Prince of Wales on 25th August 1860 drove the last spike on the Victoria Bridge across the St. Lawrence at Montreal to mark its official opening. And the engineer responsible for this still notable structure, 6,592 feet long, the original piers of which are still in use, was Robert Stephenson whose tribute to John Smeaton I have just quoted.

Throughout this first century of civil engineering, much of the engineering work of note in Canada was carried out by British engineers, or with their assistance. The legacy left by British engineers was a notable one, providing a firm foundation for Canadian work of the succeeding century. It is a tale well worth the telling but it constitutes only a chapter in the overall story of the development of Canada. Brief tribute, however, must be paid even in this passing reference to the

great contribution of the men of the Royal Engineers, on both east and west coasts, the building of the Rideau Canal (1827–1832) being perhaps their greatest achievement, the great arched dam at Jones Falls, a world's record at the time of its construction, being still a notable structure today.

Naturally, as in all human developments, there was no hard and fast dividing line but rather a period of gradual but steady transition. Samuel Keefer, for example, had begun his long and distinguished career in the eighteen thirties and Thomas Keefer his rather longer career in the forties, both men having been born in Ontario. Sir Casimir Gzowski arrived in Toronto in 1841 to begin his notable engineering work on harbours and railways. Dredging of the St. Lawrence Ship Channel in order to improve the approach to Montreal started in 1844. Three years before this, under the Union of 1841, the first Commissioners of Public Works had been appointed to take charge of the simple engineering works then required by the provinces of Upper and Lower Canada, this being the real start of what is today the federal Department of Public Works. And many of the early members of staff serving the Commissioners were native born Canadians, practical engineers who served Canada well in those early days. The opening of the Victoria Bridge, however, seems to provide a turning point in the history of civil engineering in this country. Thereafter one finds British engineers still filling advisory positions for Canadian work but eventually even this service was called for on special occasions only.

Little more than twenty years after the Victoria Bridge was opened a man in stained and ragged clothing managed to persuade the portly butler in a magnificent mansion on Drummond Street in Montreal that he was not a beggar but should be announced to the master of the house, even though he was at dinner. The host who finally welcomed the traveller was George Stephen; the man in rags Major A. B. Rogers, come out of the West to report in person on his discovery of what was to be called Rogers Pass, the first way through the Rockies for the C.P.R., today being used again for the Trans Canada Highway. The completion of the Canadian Pacific Railway was another focal point for civil engineering in this

country. Thereafter in quick succession came the building of more railways, many notable bridges, canal improvements, the pioneer water power plants, the first municipal utilities.

The opening of another notable bridge marked the turn into the twentieth century for Canadian civil engineers. The Interprovincial bridge between Ottawa and Hull, more properly called the Royal Alexandra Bridge, was dedicated for its intended use on 21 February 1901, and was hailed at the time as the greatest bridge of the Dominion. Still serving its intended purpose, and highway needs also, with modifications only to its deck system, it has fallen into ill favour with the planners of the nation's capital so that its future is questionable, despite its eminence as an historic engineering structure. The fact that in the construction of its piers concrete was not permitted closer to the water surface than 20 feet is a telling reminder of the advances made in civil engineering practice in the sixty years of this bridge's service, a period well remembered by many who are still active today.

With the turn into this present century, the tempo of progress increased yet again. The vision of the times is shown by the detailed studies carried out for the proposed Georgian Bay Ship Canal Although this project did not go ahead, the building of the new Welland Canal was a reflection of the same forward-looking planning, now brought to fruition by the completion of the St. Lawrence Seaway and Power project in these, our own recent years. The completion of the Jacques Cartier pier at Montreal in 1906 set the seal of greatness upon our unique inland ocean port. The findings of the Ontario Royal Commission on highway construction in 1914 provided a sound beginning to the phenomenal growth of road building that is still in progress. Between 1900 and 1915, total railway mileage in Canada was doubled, a vivid reminder that railway building was a major activity of the early part of this century as also of the closing years of the nineteenth century. By 1910, installed generating capacity in hydro-electric stations had already reached one million horse power, clear indication of the early start of this important branch of engineering.

There were set-backs, naturally, most tragic of all being the failure of the Quebec Bridge, but even this was turned

to good advantage, constructive and painstaking study of the failure being recorded in a masterly report that is still notable as a landmark in the history of structural engineering, a report of which it was said at the time that "England itself, the home of royal commissions of investigation, has never, we fancy, produced a report that could fairly be set alongside the report rendered by these engineers." The report stands as a challenge to civil engineers of today when all too often the results of the study of failures, and especially of structural failures, are carefully shielded from public gaze instead of serving as beacons on the way to further progress. Will it surprise you to know that one of the Commissioners for the study of the Quebec Bridge failure was John Galbraith?

To go further in recording the progress of civil engineering in recent decades would be to recite a record of works of which many of us have some personal knowledge. So many, so varied and so widespread across this land are the works of the civil engineer that to give even a summary list of major achievements would mean the reading of a mere catalogue. Suffice to say that the forty thousand miles of railway line, the four hundred thousand miles of highways, the seven hundred paved airfields, the diverse canal systems, and the innumerable dock and harbour works along the long coastlines of this land on ocean and lake are indications of the contributions of the civil engineer to transportation. Bridges, large and small, almost without number; industrial buildings and special structures from coast to coast; transmission towers by the tens of thousands all testify to structural skill and construction accomplishments. The twenty-eight million horse power that are today generated, from water and now from fuel also, are available for public and private use by reason of civil engineering. And the cities of Canada, their roads, sewers, water supply systems and all their complexes of integrated municipal services, are perhaps the greatest of all the contributions of the civil engineer to the well-being of his fellow Canadians, although the least spectacular and the least recognised.

It is a grand story, this two centuries of expert effort in converting an almost untouched land of forest, lake and stream

into the thriving industrial developed country that is the home and workshop of Canadians of today. Summarized thus baldly, this brief record might be taken by others than ourselves to be just a bit of unaccustomed professional backslapping. As engineers, you will know well that my purpose, in thus reminding you of the great tradition of civil engineers as the builders of this Canada of ours, is the antithesis of self-adulation. I remind you of it in order to provide background for a critical review of where we stand today, for a venture of imagination into the years immediately ahead.

Let us first, however, take note of some of the overtones to this picture of the past at which we have been glancing. In earlier days, and to some degree in the opening years of this century, the civil engineer was indeed the pioneer, literally opening up the unknown of this land with his surveys, his railway and his road building, often carried out in the face of unusual hardships. Those days have gone. The advent of the aeroplane in the North, the last frontier, wrote "Finis" to the era of the true pioneers. The whole of this vast land has now been photographed from the air. There will still be hardships to be borne, high courage to be demonstrated in the carrying out of civil engineering work in Canada, especially in the far distant places, but the opening up has been done, the main trails all blazed.

You may ask me of the North. There is development to be done there, assuredly, but on a very modest scale in the foreseeable future. With regularly scheduled air services to the shores of the Beaufort Sea, and a chain of good landing strips all along the Arctic coast, civil engineering in the North is now but little different from that elsewhere except in its economics and all that is involved in what may be called logistics, the effects of climate and geography necessitating unusual advance planning and strange working schedules.

Even more notable has been the change in the general character of engineering in Canada. Almost until the end of the nineteenth century, engineering in Canada meant civil engineering. Mechanical engineering and mining engineering had been recognised, but were subsidiary in importance even at the turn of the century. How quickly this situation changed.

Mining engineers, mechanical engineers and electrical engineers were soon making their own notable contributions to Canadian development. Chemical engineers joined in later, and still more recently aeronautical engineers, to mention only the leading divisions now recognised within the profession of engineering. The change found public expression in 1918 when the Canadian Society of Civil Engineers, then more than thirty years old, changed its name to the Engineering Institute of Canada, symptomatic of the engineering team work that was beginning to characterize all larger projects.

This particular trend has continued, quite logically and naturally, to the present time. With the attention of the public diverted by all the arts of mass communication to the undoubted wonders of atomic energy, and to the intriguing possibilities of space travel, it is possible that the old-time glamour of civil engineering in the eyes of the public may have become slightly dimmed. But need we be disturbed by this? Civil engineers are not alone in being the victims of such strange distortions of public attention. By reading certain selected journals, one can gain the impression that modern physics is concerned exclusively with the structure of the atom, all other branches of this very great scientific discipline being traditional, and therefore outmoded.

That there is real concern at some aspects of the present situation is no mere figment of my imagination since it is clearly shown by some recent developments across the border to the south of us. Statements have been made, and proposals advanced that can only be regarded as the result of mental alarm. We can spend our time together to better effect than by any detailed study of these evidences of concern at the state of civil engineering in the United States today. If only as corroborative evidence, however, let me merely mention that one well known educational institution, after an investigation financed to an almost astronomical degree by one of the great American foundations, is going to abandon its long established civil engineering curriculum. The new curriculum that is being adopted, while naturally concentrating upon the basic sciences, includes also such subjects as statistical theory, operations research and computer development. Useful and

excellent subjects in themselves, as replacements for subjects euphemistically called "specialised skills" these strange proposals for undergraduate courses seem to me to savour of panic thinking, carried out with no proper appreciation of the role that civil engineering is filling today and will surely continue to fill for many decades yet to come.

What is this role? A recent suggestion from across the border is "the fulfilment of human needs through the adaptation and control of land-water-air environment".* This seems to me to be somewhat less satisfactory than the 140-year old definition of Thomas Tredgold, written for the Institution of Civil Engineers, which suggested that civil engineering is "the art of directing the great sources of power in Nature for the use and convenience of man". This is the elegant phrase usually quoted, but Tredgold went on to say that civil engineering is therefore "that practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon, and changed the aspect and state of affairs in the whole world. . . . Its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical and chemical art since its bounds are unlimited, and equally so must be the researches of its professors."

"Changed the aspect and state of affairs in the whole world"! This is a telling phrase, potent with meaning, ringing with challenge. If Tredgold could suggest this in 1828, how much more valid is it today. But the key to the statement is surely provided by the words "for the use and convenience of man", this thought being reflected in the more flamboyant modern reference to the "fulfilment of human needs". It is indeed for the direct use and convenience of his fellow men that the works of the civil engineer are executed—transportation facilities of all kinds, power supply, water supply, sewage disposal, irrigation facilities, drainage works and the foundations of all structures, for whatever purpose they may be intended—so the list can be continued. Although its bounds are not exactly "unlimited" in the colloquial sense in which this word is used today, they are literally unlimited, the civil engineer having

*See Civil Engineering (New York) Vol. 31, No. 1, p. 57, January 1961.

to stand ready to assist with structures for and the construction of all new developments whatever they may be—launching pads for rockets to the moon or a power station in which a nuclear reactor is to be installed, to mention just two currently popular engineering projects.

Limitation of scope by precise, and concise, definition appears therefore to be a semantic exercise of little real value. This will be found to be the case with all very old human activities, and civil engineering is indeed very old. Jointly with architecture, civil engineering has its roots in antiquity. Almost alone amongst what are so quaintly called the "mechanic arts", these two professions, separately or together, can look back on an unbroken history of well over two thousand years. Their work developed in providing shelter for man and his diverse activities, and for his convenience, safety and service in the communities in which he lived and worked. The really wonderful modern developments of other branches of engineering—mechanical, electrical, chemical, aeronautical—naturally serve mankind also, but inevitably within the framework of shelter and service provided by architects and civil engineers. By the very nature of the respective callings, this must always be so. Why, then, the questions about the future of civil engineering? The questions might possibly be addressed more properly to civil engineers—asking them if they have kept clearly before them their social responsibilities, whether they have accepted fully their vital role of co-ordination in the prosecution of engineering works, demanding of those who teach civil engineering whether they have made crystal clear to their students the high professional calling that is to be theirs, sending them forth upon graduation with the challenge of the years ringing in their ears?

If the concept of co-ordination sounds an unfamiliar note to you, I am confirmed in my belief that it is civil engineers who need to be questioned about their future, rather than that doubt should be cast upon the future of civil engineering. Just as in the design of a modern building, one man must co-ordinate the efforts of all the experts who are contributing to the design of the finished structure, the co-ordinator or leader of the team being naturally and rightfully the architect

for all but engineering structures, so in the case of engineering works—from the simplest bridge to the most complex hydro-electric development or chemical plant—the linking together of the various units (naturally designed by the appropriate experts) and the provision of the necessary essential services is the high calling of the civil engineer, as is also the carrying out of the necessary construction operations.

So accustomed are we, as civil engineers, to the fact that construction operations are an integral part of civil engineering that we may be guilty of having failed to make this clear not only to the public but also to the young men at school in search of a profession. In like manner, although we commonly talk about the wonders of structural engineering, have we not neglected to make plain that the engineering of cities (municipal engineering is the more mundane name) is an equally vital part of civil engineering? Do not think that I am suggesting anything carrying the taint of Madison Avenue, any so-called "public relations programme", any shouting from the house tops. Nothing like this, but what I am suggesting is that, for a variety of reasons that I shall not now attempt to define, we may have failed to let it be generally appreciated (and especially by young people) that civil engineering, far from being outmoded and a relic of the past always practised by bewhiskered gentlemen inevitably attired in knee breeches and high boots, is in the van of all parts of modern engineering, with its own specialist branches demanding the highest of scientific skills, but firmly rooted in public service and demanding in most of its branches a capacity for dealing with people, either as co-ordinator or as adviser to lay bodies, that is unique to civil engineers within our profession.

Let me revert briefly to municipal engineering if only to direct your attention to the presidential address recently given in London to the Institution of Civil Engineers by Sir Herbert Manzoni.* This was a masterly exposition of the work and duties of the municipal engineer, for Sir Herbert has long been the very distinguished city engineer of Birmingham. But even he has to admit that:

*Proc. Inst. Civil Eng. (London), Vol. 18, pp. 1–14, January 1961.

Only in the most rare instances does a municipal engineer become famous or even notorious outside his family circle, and then usually by accident, a crime, a facility at public entertainment, or even an unusual name. (But Sir Herbert goes on to say that:—) For his very obscure but very onerous life's work he will not become wealthy in material things but he will have enjoyed one of the most interesting and useful careers available anywhere in any profession.

Sir Herbert naturally stresses the factor of co-ordination that I have already mentioned and points out that the time is long passed when the city engineer can be a specialist in the many types of engineering for which he is responsible. He must, however, be reasonably familiar with these several branches of work, so that he may know when experts should be engaged and be able to advise the public bodies he serves. For, as he says,

In the public service, where the client is the public or their representatives, they often have little defined knowledge even of their need and less of the available means of its satisfaction. Some one person has to become aware of such needs and often has to use much persuasion to convince sufficient people to support a proposal which may involve much expenditure and the benefits of which are little understood.

This is well illustrated in the case of town planning. Even though comparisons may be "odorous", may I quote again from Sir Herbert Manzoni in order to reinforce what I want to say about planning in our country? Speaking of Great Britain he was able to say that

municipal engineers have carried out almost the whole of the town planning work in this country from its inception to the time of the 1947 Act. In company with a very few civil servants . . . they have developed its technique, set the pattern for its legislation by experiment, and carried out its practices to the culmination of its latest professional status. They have made of it a model which the rest of the world seeks to follow far behind and which claimants seek to inherit by envious attack.

Contrast this situation with the status of planning in Canada. You will see at a glance confirmation of what I have been saying about our failure to make known what civil engineering really is. Some of the most notable of the early town planners in Canada were civil engineers, but where are the civil engineers in relation to current planning activity in this country? Unfortunately they are conspicuous mainly by their absence.

By default, and with no-one really to blame but ourselves, we have allowed this vital field of public service to be generally pre-empted by others—self-styled planners, architects and even geographers. I have many good friends who are geographers and I have a healthy respect for geography but I must admit that when, some years ago, I heard a well known geographer say at a dinner in Ottawa that the great success that had attended the planning of the great work of the Tennessee Valley Authority was due to the fact that there were six geographers on the T.V.A. staff, I almost imagined I was taking part in the Alice-in-Wonderland sort of nightmare.

Some of you may know how earnestly I desire to see civil engineers and architects in Canada co-operating much more closely than has been the case since the very early years of our development, to their mutual benefit. Let me, then, hasten to add that I realise that architects have a great deal to contribute to real town planning, in co-operation with engineers. At the same time, I fail to see why all instruction in town planning given in the universities of Canada is given in the Schools of Architecture and not jointly by civil engineers and architects. I know of no other activity in which the closest co-operation between civil engineers and architects is not only desirable but absolutely essential with the civil engineer, in this case, being the acknowledged leader of the team.

Civil engineering in Canada today has an enviable world-wide reputation. In water power plant design we need take second place to none, the Robert Saunders station on the St. Lawrence and the Warzak station on the borders of Afghanistan being recent examples at opposite sides of the world that pay mute testimony to the assertion. In the design of bridges, roads, railways and canals we have many fine examples to place beside the best from elsewhere without fear of discredit. The cities of Canada are served by as loyal and efficient a group of municipal engineers as can be found anywhere. The early achievements of the Ontario Water Resources Commission are already commanding international attention. And in the practice of heavy construction I am quite confident that Canada is pre-eminent, the building of the Shipshaw power plant, of the Polymer plant at Sarnia, of the Kelsey plant in

far northern Manitoba, and of the Dew Line in the high Arctic being but a few of the many examples that are almost without equal.

But when it comes to town and country planning and the contributions of civil engineers to the betterment of our cities, the picture is not quite so bright. It is true that much notable work has been done by engineers; many civil engineers are serving faithfully and well, but also silently, in some of the planning activity that is going on in Canada today. Planning, however, must once again be generally recognised as essentially an engineering function. I say this not in any foolish proprietory sense but for the very matter of fact reason that sound planning cannot be carried out without due recognition of ground conditions, the limitations that these place upon subsurface work, and the existence of works and utilities already in service. Beyond this, the very essence of planning is the co-ordination of the varying demands made of any plan, the welding together of diverse interests and the skills of different disciplines with the objective of finding the best possible sound and economic solution, always and necessarily a compromise. And how better can the process of civil engineering design be expressed than by such words, an equally accurate outline of the planning process?

When the civil engineering aspect of planning is again recognised, then we may hope to avoid occurrences such as the siting of a housing development all the house services for which had to be located in trenches blasted in solid rock, the planning of a new town with attention given only to the topography of the site and not to what lay beneath the surface, the subdivision of a city for so-called planning purposes by using the street layout without any reference to the arrangement of the subsurface utilities, and (a feature to be found not only in one city I know well but in several) the complete separation of traffic engineering from the direction of the city engineer, as though traffic operated in vacuo. What do civil engineers now do or say corporately about such matters? Nothing. This is a change from the past when the Engineering Institute of Canada, and its predecessor the C.S.C.E., on both the national and local level took a lively and public interest

in planning matters, convening public meetings, preparing briefs, interviewing officially those in Government.

Some may complain that this would mean contact with the public, as though this were something reprehensible, something new. Canadian civil engineers may well look back to their leaders of yesteryear for full and sufficient answer. Think of the public statements and activities of Fleming, of the Keefers, of Gzowski—all well known national figures *and* civil engineers. Recall that Walter Shanley was the friend and confidential adviser of Sir John A. Macdonald. A new development? Think farther back still if you will, as I give you a brief respite from listening to the plain and mundane words of an engineer while I quote some lines from the writing of one of the most lucid of English historians. Writing of "Restoration England" (his fine book upon which has recently been reissued) Sir Arthur Bryant tells that in the England of the sixteen hundreds,

"Every parish was responsible for the upkeep of its own roads, and for providing an officer each year to see that this was done. This functionary, called officially the Surveyor of the Highways, or more usually Boonmaster or Waywarden, had to carry out a task that called for much tact and could only too easily involve him in unpleasant relations with his neighbours. Appointed by the Court of Quarter Sessions from a list of agricultural holders submitted by the Vestry, it was his business during his year of office to see that all whose property adjoined the public highways kept clear their gutters and drains, trimmed their hedges and refrained from stacking their manure, timber or hay on the road. If they were refractory it was his duty to name them in the parish church after sermon, giving them thirty days' notice to make amends, after which he was entitled to do so himself at their expense. It was also his duty to waylay passing carts and wagons with more than the statutory number of horses or wheels of less than the statutory width, and generally to enforce the transport enactments of Parliament and Privy Council. And three times a year he "viewed" every road, watercourse, pavement and bridge in the parish and reported their state to the Justices, subsequently, with the latters' authority, levying a highway rate to bear the cost of repairs."

I am not suggesting that civil engineers of today should report their neighbours "in the parish church after sermon" but I do suggest, as we finally take a quick look ahead, that he should take a correspondingly lively interest in the way

his works are put to public use, "viewing" them regularly and reporting upon them if not to the Justices at least to properly constituted public bodies.

As we look ahead together down the remaining years of this century there is much that is hidden from our view and even from our imagining, perhaps fortunately should the forces of evil prevail, but I choose to think rather unfortunately, certain as I am of the fundamental soundness of human progress despite all seeming difficulties and temporary disappointments. The advance of science will result in new wonders of technical skill; the frontiers of knowledge must surely still further recede. But all the inventions of the future, whatever they may be, will be of avail only when used by man and for his betterment. A man must finally "press the button" in the most automatic of all possible worlds. And it is to serve man for his "use and convenience", that the works of the civil engineer will always be required and in steadily increasing measure.

Although we shall probably see but few new railways built in Canada, road building and road improvement must continue in all parts of this land. There must eventually be a limit to this part of civil engineering if only because a man can, after all, ride in only one automobile at a time while one may, perhaps, be idealistic enough to think (or at least to hope) that with increase in education and in leisure time a growing number of Canadians may stop to ask themselves why they drive about aimlessly in automobiles. Docks, harbours and aids to navigation will long provide challenging opportunities for civil engineers interested in marine works. More and better bridges will be needed; they may also be bigger, but only if sound engineering economic analysis shows this to be necessary. There are still great water power plants to be designed and built, generally now in the more remote parts of this land, projects providing real challenge to the civil engineer in his overall planning and in detailed designs worked out jointly with his mechanical and electrical confreres. In more populated areas, the few fuel-fired steam power plants we have at present may be expected to multiply until such time as nuclear power plants begin to take their place, the civil engineering parts of all such plants being vital and complex even though

possibly over-shadowed in the public view by the fascination of the generating equipment itself. And the corresponding overall planning, detailed design of plant services, and construction scheduling for industrial plants across the length and breadth of this land will call for civil engineering work of high order. More than this, the Colombo plan projects remind us that the time has come for Canada to begin to repay her development debt by assisting the newer countries of the world with their pioneer development, the "export" of civil engineering skill being a truly heartening sign of the times.

In all this work, the appearance of his works will surely be of increasing concern to the civil engineer not only because the public may demand this but also because of the dictates of his own conscience. The civil engineer is not at heart a philistine (despite all that some architects may think). Throughout this land there are innumerable engineering structures that delight the eye by the clean lines of their functional form. One may hope that their number will increase, gradually forcing into insignificance those other structures of which we cannot be proud, always with the silent prayer that the unbridled license of much so-called modern art may never infect the clean functionalism of civil engineering design. In the case of his larger structures, the civil engineer may be expected to work more closely with the architect, in joint partnership such as has already proved to be so effective. Correspondingly, one may hope and, indeed, I think expect to see architects willing to work more closely with civil engineers on their own building projects, again in joint partnership and not by "fitting in the engineering after the building has been designed", reverting in a sense to the old concept of the master builder, but now the team rather than the individual.

It is in the engineering of cities that I think we shall see almost the greatest advances in civil engineering in the years ahead, not in the type of work done but in its scope and extent. All too many smaller cities still have no city engineer—and they show it. Many cities that do have an engineer give him little or no support for the works he knows to be necessary in making the smaller cities of Canada a credit to this land. Only in this way and by an awakened public opinion can we hope

to stem the tide sweeping more and more people into our few great metropolitan areas—surely too large already? Old street layouts have to be revamped, open spaces cleared for public delight, railways relocated for optimum convenience (and not relegated to "outer darkness" as seems to be the predeliction of some non-engineering planners), airports linked conveniently with civic centres, fringe developments controlled, off-street parking provided without too much waste of open space or valuable land. Even the listing of such projects excites the imagination as one thinks of them in relation to some well remembered potentially beautiful city. But they are almost of minor importance when compared with the supplying of pure water to cities and towns and the corresponding collection and purification of waste waters and sewage. Here is perhaps the greatest challenge of all to the civil engineers of the decades immediately ahead of us.

For it is the high privilege of the civil engineer to be the public servant through whom the renewable natural resources of this land are developed and put to use. So also must it be his responsibility to see that they are conserved. And of all resources, water is in many ways the most vital of all; certainly without it life is impossible. How profligate we have been in squandering and in spoiling our supplies of pure water! How many of our streams are still unregulated, still foul and filthy through the uncontrolled discharge into them of untreated wastes, industrial and human alike. Great progress has been made in the last two decades. Above all has been the establishment of the Ontario Water Resources Commission with its clear mandate to treat water as a public treasure to be used and yet conserved in the public interest on a regional rather than upon any limited local scale. The conservation activities sponsored and developed by the Department of Planning and Development must also be acknowledged with pride and appreciation. And the Engineering Institute of Canada is now preparing to make public submission about water polution on the national scale.

A fine start has been made, but only just in time. How much there is still to do is a tale in itself. We must content ourselves by recognising this challenge to the civil engineers who are to

follow us, many of whom are going to be trained in the new building. How should they be prepared for the tasks that are to be theirs? Certainly not by instruction as undergraduates in "computer development" or indeed in any such highly specialised subject. Specialisation can come later after the young men have graduated, found their interests and return of their own free will to selected specialist study. And "the best basis for successful specialising is a sound general training" (I quote John Galbraith).

Let me enter the lists of educational fray with the strongest possible unqualified plea for such general training, which I regard as essential for all engineering undergraduates but especially for those who elect to study civil engineering. Based upon the foundation of sound and disciplined general knowledge that the high schools should and must provide, let there be erected a firm appreciation of the basic sciences and mathematics, with mechanics given its rightful place as perhaps the greatest of all aids in developing the engineering outlook, that facility of visualising problems in three dimensions and confining them to paper for analysis. Let surveying come to occupy its proper place in all curricula, not as the poor relation of the course but revitalised and brought up to date as the theory and practice of measurement, a matter in which all engineers should be well versed. Lord Kelvin's famous dictum still holds true. The essentials of applied science, in hydraulics, thermodynamics, electrical theory, and structural design must form the hard core of the course but so taught with constant reference to library material that in later years the graduate "even if he has forgotten how to apply the sciences, knows at least where and how to get the information he requires without loss of time" (Galbraith again).

It is Albert Einstein who has so provocatively suggested that "imagination is more important than knowledge". Whether one agrees with this or not, it will be generally agreed that the imaginations of undergraduate engineers must be awakened while they are in university halls, alike in the picture they get of the high calling that is to be theirs as in developing the ability to visualise clearly a structure or machine long before it becomes even a design committed to paper. It is here that

engineering drawing, in my view, can prove to be an inspiration to the young engineer instead of the drudgery which one hears so often described, especially if it includes a rigorous introduction to freehand sketching, a facility that every civil engineer should possess.

Imagination is also essential if proper appreciation is to be given to what I firmly regard as the most neglected part of most civil engineering curricula, our own Cinderella. Every civil engineering work has some contact with the ground, and ground conditions are never the same in any two locations. Surely, therefore, a basic part of all civil engineering courses should be an introduction to the study of subsurface conditions through geology and through soil mechanics, subjects certainly as important as advanced structural theory, since every civil engineer is going to have to work at some time with the ground. New thinking in this direction has been shown at the University of Melbourne in Australia which now has a splendid combined course for civil engineers called Earth Science, embracing basic geology, engineering geology, soil mechanics and the beginnings of foundation design. I hope to see this fine example soon followed in Canada. I think also of practical knowledge of the ground. It is my conviction that no young civil engineering student should be permitted to graduate until he has spent at least one summer on a construction project. He will learn much, not only about the ground but about his fellow men and management.

All this can be done only with absolutely first class students. Civil engineering is assuredly not a course into which students may drift if not admitted into other much vaunted scientific courses. Only the best will do—for a course that embraces something from all the sciences, from mathematics to biology, but one that goes beyond science. If only because of the breadth of its scope, civil engineering is one of the most demanding of all disciplines.

Clearly, a start only can be made in the limited time of the undergraduate course. Accordingly should not a certain prospect for the future in civil engineering be a great increase in post-graduate training, geared to meet the times, much of it given in evening hours? In this way the necessary training

can be continued for those who are going to open up new paths in structural design, to improve the practice of foundation engineering, to pioneer in advances in power and industrial plant conceptions, above all for those who feel called to exercise the planning function, for those who find the supply and purification of water a challenge.

Post-graduate training, of which this is merely a glimpse, can naturally be effective only if basic undergraduate work is sound and broadly based, upon such essential ("old-fashioned" if you will) technical subjects as have already been mentioned. Beyond all such technical subjects, however, is that wider training that alone is going to convert the school-boy into the embryonic professional man. He must have his eyes opened to "faery lands forlorn" through the medium of books. It is Dean Galbraith speaking once again (with me in respectful but strong support) when I say "that the chief object of a school of applied science is to train its graduates in such a way that they are able to read".* They must read widely and they must be able to speak in public of what they read since, as civil engineers, they must be able to explain to lay groups the intricacies and the significance of civil engineering projects.

Above all, they must be inspired—inspired with a vision of the grand sweep of human knowledge, so interestingly essayed in this Faculty by the silver strand of non-engineering subjects running through all four years of study, inspired with the challenge of all that civil engineering is going to mean in the years ahead, a vision such as we have been glimpsing together in this hour, well founded in the past, acknowledging that the days of the pioneer have gone, accepting the present, but looking hopefully to the challenge of the future, knowing that just as Canadian civil engineers of the past opened up all parts of this great land, so civil engineers of today and of the future now have the responsibility of developing it well for the "use and convenience" of their fellow Canadians, and of ensuring that its renewable natural resources—water above all—are conserved till the end of time.

*All quotations from Dean Galbraith came from the speech he made at a dinner in his honour in December 1900 as reported in *University of Toronto Monthly*, Vol. 1, pp. 148–154, January 1901.