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CIVIL ENGINEERING SERVICES

CITY COUNCIL OF JOHANNESBURG

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CIVIL ENGINEERING SERVICES : CITY COUNCIL OF JOHANNESBURG.

HISTORICAL:

It is difficult to explain the function of the Civil Engineer in any particular field to laymen and the uninitiated - that is, those who have not come in contact with Civil Engineers in the course of their day-to-day occupation. The difficulty is accentuated because so few members of the public ever do come into contact with the professional engineer. Most people have need at some time or other to consult members of other professions, for instance, doctors, dentists, lawyers, architects and so on, but few want to build bridges, dams, water supply schemes and so on. They do have occasion to meet plumbers, motor mechanics, refrigerator repair men, electricians and the like, and, as the latter are regarded as falling in the orbit of the engineering world, and may even term themselves sanitary engineers, motor engineers, refrigerator engineers, electrical engineers and so on, they conclude, if they do take the trouble to think of the matter, that Civil Engineers are some close kith and kin of the tradesmen, who manage to wear white collars for part of the time, and who have some vague connection with large public works.

To sum up, the image of the Civil Engineer in the public mind is very hazy, or blurred at the best.

Before the role of the professional Civil Engineer in Local Government can be discussed and appreciated, therefore, it is first necessary to sketch something of the historical background of his profession and give a brief description of his work and responsibilities in modern society.

The profession of a Civil Engineer is described in the Royal Charter granted to the Institution of Civil Engineers, London, as:-

> "... being the art of directing the Great Sources of Power in Nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, ... and in the drainage of cities and towns".

This is a broad generalised picture which does little to enlighten the average reader, but defines the field of the Civil Engineer at the time the Charter was granted in 1828.

In earlier/...

In earlier days, large public works were usually constructed by the state through the agency of Military Engineers; the motivating reason being usually state defence, both internal and external. It was not until the time of the industrial revolution that public works achieved a sufficient importance to demand the creation and attention of a specialised profession. It was because the nature of the works designed and constructed by the new body of engineers was similar to those performed by the Military Engineers that the new engineers were called Civil Engineers to distinguish them from the Military Engineers.

It does not require any deep study for us to appreciate that our modern way of life is completely dependent on the services performed by the Civil Engineer. It is only because it is a large-scale public service, and not a personal one, that the general public is unappreciative and unaware of the professional Civil Engineer's contribution and existence.

In keeping with the important role he has to play in the economy of his community, the Civil Engineer must undergo lengthy and rigorous training. The general standard required is an extremely arduous four year course at university leading to the degree of B.Sc.(Eng.). This course is acknowledged to be one of the most difficult and demanding at the university.

SERVICE TO LOCAL GOVERNMENT:

Engineering service to the public is probably the main pre-occupation of Local Government. Ratepayers pay their rates and taxes to the Local Authority and expect, in return, the provision of the amenities of modern city life. They want good roads and motorways to give easy communication between their places of residence, work and play. They want a plentiful supply of clean pure water and a drainage system and refuse removal service for convenience and the protection of their health. They also want stormwater drainage systems as protection from floods, and large buildings for public functions, to house their public libraries, art collections and park their cars. They also want electric power, fire protection services, parks, swimming baths, a market and possibly an abattoir. Above all, they want an attractive vital city which is not only a pleasant place to live in but which also affords them the opportunity to earn the good remuneration which is essential to maintain a high standard of living.

This all/...

This all demands a city well planned for the present, and the future, in which these necessary services are provided at the most reasonable cost possible.

This, in brief, is the field of the Civil Engineer in Local Government; it can be readily appreciated that his work is largely that of his colleague in general practice and the only distinction to be drawn is that whereas the Civil Engineer in general practice will tend to specialise in a restricted part of the vast field covered in the profession, his Local Government counterpart will perforce have to cover, and be expert in, a much wider spectrum.

It is self evident from these considerations that the Civil Engineer is the key man in Local Government and on his efficiency and expert knowledge depends, to a large extent, the efficiency and economy of the Local Government service itself. This vital factor requires to be discussed in more detail, but it will first be of interest to consider this city, Johannesburg, itself to see the service demanded and given in its phenomenal growth.

THE GROWTH OF JOHANNESBURG:

Consider the growth of Johannesburg since the end of the war, that is, in a period of some sixteen years.

The European areas of the city have not grown a great deal, the present area being 60,453 acres as against 57,007 in 1946. The Bantu areas, however, have experienced quite phenomenal growth. At the end of the war Orlando and Pimville covered less than 1,000 acres, while the south-western complex, known as Soweto, now covers 13,389 acres. What was a small location with one or two tarred roads and a rudimentary water system, is now a bustling town with a population of 467,159, fully provided with waterborne sewerage and its own modern sewage purification plant, a well developed network of properly constructed roads, street lights, community centres, schools, churches, places of recreation including modern sports stadiums, and even the nucleus of its own civic centre.

All this has risen from the bare veld, largely by the efforts of the Council's Engineers in sixteen short years. Not only has it been created, but it is being maintained and given full engineering services by a branch of the City Engineer's Department. The organisation of this section alone is in effect that of the City Engineer's Department of a large town; as far as population is concerned, Soweto would, if an independent municipality, rank

after/...

after Cape Town as the fourth largest town in the Republic.

The growth of the city, the services required, the financial position and staff of the department are best represented diagramatically. A study of this presentation shows that the city has almost doubled in size in the years since World War II.

The department has not, however, doubled in size in this period; there has been a large increase in salaried staff, a smaller increase in skilled labour - mostly European - and a slight reduction in the unskilled labour force - mostly Non-European.

This has arisen from various causes, mainly regular minor re-organisations of the department to meet new problems; the adoption of the policy of carrying out construction, where possible, by contract; and mechanisation of many operations previously carried out manually, for example, refuse removal, trench excavation and so on.

It has been found that contract prices are generally keen and the costsof works carried out by free enterprise are lower in general than if carried out by departmental labour. Some works are, however, better carried out by direct labour. These include road re-construction and widening where traffic conditions make operations difficult, water reticulation, some relief sewer construction, extensions to sewage purification works and many minor works.

The maintenance of a skilled labour force to carry out such works has proved a very useful adjunct to the operation of a force required for maintenance works and provides flexibility and a pool from which experienced Inspectors, Clerks of Works and so on can be drawn for the supervision and control of contract works.

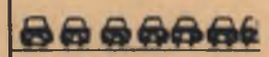
A further and significant factor, which has led to the increase in the salaried staff, has been the improved quality of technical engineering service which is now possible from major developments in the science and techniques of Civil Engineering. This aspect is discussed in detail later in this memorandum.

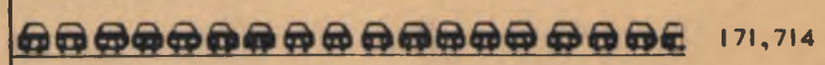
THE VALUE/...

CITY GROWTH

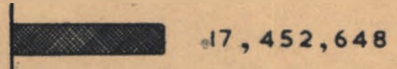
POPULATION

MOTOR VEHICLES





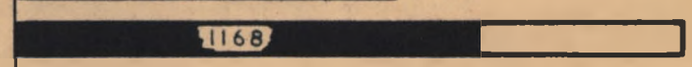
RATES. (MILLION RAND P.A.)



SERVICES

SEWERS (MILES)

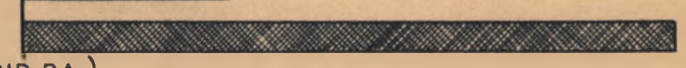
ROADS (MILES)



REFUSE (TONS/DAY)

ANNUAL EXPENDITURE

REVENUE (MILLION RAND P.A.)



CAPITAL (MILLION RAND P.A.)

STAFF

EUROPEAN

SALARIED

DAILY PAID

NON EUROPEAN

THE VALUE OF THE ENGINEER'S SERVICE:

The value of the Civil Engineering service to the community as mentioned earlier is unfortunately seldom, if ever, considered. Some idea can, however, be given of the scope of the service to the modern city; the actual value in hard cash can also be appreciated.

The common lay idea of a municipal engineering service is a vague compounding of public health inspection, roads, parks and pavements. This may have been correct in the past, and it was, in earlier times, the function of the Civil Engineer in municipal service to passively provide a neutral background of secure health, well ordered traffic and cultural service against which the more vigorous burgeoning life of the community could be enacted. In such a duty the engineer's functions were limited, and the knowledge and administrative skills were not great.

The position today is entirely different, however, and while the old order may be unchanged in most municipal departments, the change in the Civil Engineering field of municipal service is fundamental. The old style of municipal engineering is totally inadequate to new needs which have developed quite suddenly. It is only a very short time since the depth of the field covered was so shallow that one man could reasonably claim to have had experience in all the branches of the department.

This is no longer possible. In the short period of the last ten years the various fields of municipal engineering have so increased in scope and depth that it is a fortunate engineer who can command even one specialisation fully.

This has been brought about by two factors. Firstly, big cities have become big business, and secondly, there have been revolutionary developments in Civil Engineering service, the application of which to the municipal field means broadly that an improved service can be obtained to meet modern demands, usually at lesser cost.

Modern cities are being involved in large construction. There has been a revolution in large-scale construction and engineering technique. It is no longer sufficient to have a man to look after pavements and stormwater; the type of man who can design and build small projects reasonably well. New projects in the city are going to cost millions. To ensure that the city is to get the greatest value for this expenditure, the old type of man will not do. The work of the city must be done by highly qualified specialists

following/...

following far-reaching long-term plans prepared by experienced experts. Not all the specialists who will be involved can be expected to find a career in the Council's departments and recourse must be made to specialist consultants who themselves specialise in certain aspects of design and employ highly paid experts. The Council's senior supervising engineers must be able to match these experts, to judge their work, however advanced it may be. The designs are going to be executed by some of the great contracting firms of the country. Again, the Council's project engineers must be men who can meet the contractor's experts on equal terms with the authority of wide experience and high qualifications.

Let us examine the details of this picture:

Road construction is the perennial concern of a city and an operation that is more familiar than most to the citizen, particularly when he finds, at times, that he is deviated from his usual route by roadworks.

In the past (and the past in this context includes the post World War II years), the general practice adopted for road design was to design on a basis of experience, or engineering judgment. The engineer would visit the site, decide on the basis of visual examination or elementary tests whether the subbase was good, indifferent or bad and, depending on the volume and class of traffic to use the road, would specify a depth of road construction and thickness of wearing surface. Inevitably by the application of such a process precision was impossible and the tendency was to err on the conservative side; roads were consequently constructed rather more heavily than is now known to be necessary. On the other hand, failures, where the engineer's judgment of foundation material let him down, were possible and were not unknown. The overall result was a higher than necessary initial cost of construction plus an additional cost of maintenance, or too early reconstruction, where failures occurred.

The modern methods adopted by the department are in line with the best current practice in the Republic. These lie in the application of soil mechanics. This branch of Civil Engineering is one which has taken tremendous strides in recent years, and refined and extremely complex theories of soil characteristics and behaviour have been developed. Numerous practical tests and methods of examining soils have flowed from this, with the result that a highly efficient complex tool is now available for the designer. He requires, of course, increased skill and education to apply the science, but the outcome is most significant.

Soil samples are now taken by the department as an essential preliminary to road design and are subjected to careful testing and analysis in the department's soilslaboratory or in outside specialised laboratories. The results are employed in the design branch so that an accurate and

precise/...

precise design is achieved. The result is, in general, lighter construction and rare failures; both of which mean reduced costs.

A similar process applies in the surfacing of roads. New knowledge available of bitumens and materials has made it possible, with expert supervision, to reduce the costs of surfacing and resurfacing. At the same time, the improved quality of the wearing surface is giving an extended life.

These points can be illustrated by considering actual costs:

In the Harrow Road Scheme, for example, two main carriageways 3,100 feet long have been constructed by contract. On past methods, a depth of construction of 12 inches would have been adopted throughout, but present design revealed that the actual depth of road construction should vary along the route from 9 inches to 29 inches. The road was constructed on this basis at an actual saving, by the contract prices, of R3,300. This may seem a small amount compared to the cost of the work, but it should be noted that at least 50% of the road has a constructed depth greater than 12 inches and this portion would have failed and required reconstruction at a very early date.

On a similar basis the saving on the Heidelberg Road Scheme was R11,700 though on this project, due to uniformly good base conditions, failures would have been much more limited.

Similarly for road resealing. The annual expenditure on this operation by the department on minor roads is R250,000. Savings in material costs, arising from the application of new techniques and improved supervision, are calculated at 5.3% for single seal and 5.6% for double seal; an annual saving of R13,800. With an estimated extension of the life of a single seal surface from five to seven years, and a double seal from seven to nine years, additional savings of 30% and 22.2% can be expected. This amounts to some R58,000 per annum.

Major routes are surfaced with a longer-wearing, higher quality surface -- the premix veneer carpet. The life of this surface depends on the binder content and the grading of the aggregate as well as the texture of the final product.

Strict control of these factors does increase the life of the premix considerably. The actual annual expenditure on such surfacing is about R130,000 and if the life is extended from twelve to sixteen years, which is a conservative estimate, the annual saving will be nearly R32,000.

Sewage/...

Sewage purification is another important field of the Civil Engineer in municipal service though, unless poorly managed, the function seldom comes before the notice of the public. Here we find that South Africa, due to its peculiar conditions, has taken a lead and has been accorded world wide recognition. It is a matter of pride that Johannesburg's own experts have been very largely responsible for this achievement and, while South Africa is rightly regarded as being in the van of waste water treatment and reclamation, Johannesburg is accepted both in the Republic and overseas as a leading example of enlightened policy. It is on record that Johannesburg's sewer system and purification plant was recently held up as an outstanding example of modern sewage practice in no less a forum than the British House of Commons.

This very satisfactory state of affairs stems from the way in which the engineering and chemical staff has met the challenge posed by the siting of a large modern city on a watershed with no permanent large bodies of receiving waters and a limited source of raw water.

Such recognition and benefits have not been lightly won and have only been possible by reason of the devoted application of members of the staff.

Satisfactory as the present position is, however, it cannot be allowed to remain static. The city must continue to retain the services of the staff of experts it now enjoys and this staff must progress with the times. This means, in sewage purification practice, that the engineer must keep abreast and be familiar with modern thinking and the vast amount of fundamental data becoming available from the specialist bodies devoted to research, which have comparatively recently come into being. An example is the National Institute for Water Research. The city must also be prepared to co-operate with these organisations by adapting the results of fundamental laboratory research to the plant scale, and carrying out the necessary large-scale research work. This work can no longer be adequately done by the non-specialist engineer who is involved in many day-to-day problems and has not the leisure to devote to the study of the present flood of technical literature.

In effect, the day of the amateur research worker in sewage purification is past and it is unthinkable that this city should do otherwise than make room in the ranks of the technical staff for expert professional specialists in order that the city may reap the benefits of new knowledge.

An example of developments in store relates to the liquid phase of waste water purification. This is basically an aerobic process in which

biological/...

biological life is stimulated by the provision of oxygen and nutrient (from the polluted water) to reduce the putrescible content of the liquid to acceptable limits.

The best known and proved methods known are to achieve this either by the use of percolating filters or by activated sludge plants. The former has been developed and modified to a high degree of efficiency, and has been adopted in Johannesburg. Unfortunately, both processes have the defect that the nitrogen present in the sewage is converted to nitrate. This is a stable compound but nevertheless is not a welcome constituent of effluent in that it can cause methaemaglobaenaemia if consumed by young children, it can give rise to algal "blooms" in stored recuring waters and it can be the cause of corrosive attack on concrete if used in industry.

This problem is world wide and no solution has been forthcoming from outside authorities. Large scale experimental work carried out at the Northern Works by a few of the Council's experts has adapted the known process of using maturation ponds to such a degree that full stabilisation of large volumes has been achieved without the formation of nitrate. This plant has run for many months but the process is not, as yet, fully developed and has proved unsuccessful in the winter months.

This research work must continue, but progress is painfully slow because of the lack of fulltime research men.

On the economics side, incidentally, the picture is most promising, and it has been calculated that stabilisation of an effluent by the new process will reduce costs of treatment from the present 3.4 cents to 2.6 cents per thousand gallons. For a works the size of Johannesburg's new Northern Works this will mean an annual saving of R57,500.

A few examples have been given of some real savings which the Civil Engineer has won for the city by the increased technical skill which he is called upon to provide. There is, however, another side to the coin; the engineer is not only applying new skills to achieve saving, but also to provide the higher quality service demanded by the modern growing city.

Some of these techniques were unknown to, and even unsuspected by, the engineer of the last generation, but have now reached the stage of becoming the subject of discussion by enlightened laymen. Examples which come to mind of new fields are Traffic Engineering, Prestressed Concrete and the use of Electronic Computers.

Traffic/...

Traffic Engineering alone is a vast field on its own which the engineer specialist must master to plan and implement the motorway and major road schemes. It is not possible in this report to give any real insight into the complexities of the geometric design of motorway interchanges, the effect of motorways on traffic flow pattern, the carrying out of desire lines of travel surveys, the assignment of traffic and so on. Some indication can be given, however, from the fact that a traffic engineering course embraces usually a full year of study at post graduate level.

In Johannesburg it has been necessary to send two experienced engineers to complete such courses of study at universities in America; a third is presently following the course. The two engineers who have returned have disseminated the knowledge acquired to keep the department's staff up to date, so that the department has the very necessary core of experts to form a specialised traffic engineering section.

Prestressed Concrete is in many applications succeeding normal reinforced concrete as a more economical and satisfactory construction method. The prestressing of concrete involves a far deeper understanding of the basic materials, concrete and high tensile steel, and the adaptation of elastic and plastic theories to the design process. It is a field with which the Civil Engineer must be conversant if the most economical and aesthetically pleasing structures are to be built. The science is so new, however, that even now very little is taught at under-graduate level at our universities and engineers must acquire the necessary knowledge from current technical literature and practice or specialised post-graduate study.

Electronic Computers, both digital and analogue, are being increasingly applied in many fields of interest in modern society. They are being used in the Council, for example, for calculation of monthly water and light accounts, an operation for which certain computers are eminently well suited.

Specialised computers, such as the I.B.M. 1620 at the Witwatersrand University, are designed specifically for intricate mathematical calculation, and are being increasingly used in engineering design. The department has already had occasion to make use of this tool to speed the design process and save manpower. As an example, a structural problem which would have taken about ten engineer-days to solve, was carried out by the computer in only half an hour.

The application is, however, still largely in the hands of the specialised technician who is skilled in the programming of problems, that is, putting them into the form in which the computer can absorb them and perform the necessary calculations.

The/...

The implications of the use of computers is, however, purely a problem for the engineer and can reasonably be said to be revolutionary. It demands a "new thinking" from the engineer and makes more highly specialised and deeper knowledge essential.

Considering, for example, the case of a simple continuous bridge structure. The selection of individual span lengths is in the design process fundamental to the economy of the structure. Briefly, the shorter the spans the less the depth of the beams and consequently the less the material required and the lower the cost of the deck. To offset this, reduction in span lengths makes more piers and foundations necessary, and the more piers, the greater their cost.

Until the advent of the computer, because of the time factor involved, a limited number of different spans could be investigated to determine the optimum span for economy. This has now changed and it is possible with the computer to take into account an infinite number of possible solutions and methods of construction, beam spacing and so on, to arrive at the optimum solution.

This entails the evaluation of a host of factors, such as foundation conditions, construction materials, location and so forth, all of which are dependent on increased skill, knowledge and experience on the part of the engineer.

The same principles apply to more sophisticated complex designs, though these applications are naturally far more demanding on the engineer's skill and knowledge. What is called for, in effect, is a radical change in approach to the design process in very many instances where, in the past, the trial-and-error method has been the only practical approach.

In the special field of the Civil Engineer serving a Local Authority, mention must be made of fringe zones of interest where the Civil Engineer's field merges with those of other branches of engineering or other professions. This occurs notably in mechanical engineering, mainly in so far as pumping problems are involved; sewage purification where the chemical and biological fields are involved, and in town planning which is a fast-developing discipline in which the Engineer, Land Surveyor, Architect and pure planner are all concerned. Many of the department's engineering staff have followed the part-time three year post-graduate course in town planning at the Witwatersrand University to equip themselves to play a specialised part in this field. Many others, though they have not found it possible to follow such a detailed specialised course, have been obliged to read widely on this subject so that

they/...

they can work in with and co-ordinate the work of the pure town planner.

This brief sketch cannot pretend to describe the tremendous developments in the Civil Engineering science in the past decade. Some indications of the greatly increased field have been given, however, together with some suggestion of the implications as far as the value of the services performed is concerned and of the tremendous challenge presented to the modern practitioner.

The position may well be summed up by quoting what may be termed the "credo" of the modern Civil Engineer:-

> "The community must be given maximum value for every Rand of public money spent".

To achieve this, the practitioner must employ all his training, knowledge and skill and must, at the same time, continually read and study to keep abreast of the most modern developments in his highly complex field.

SHORTAGE OF ENGINEERING STAFF: POSSIBLE SOLUTIONS:

The very real achievements of the department in recent years have been made in the face of the perennial shortage of professional staff. This shortage has become chronic and though sporadic attempts have been made to overcome the problem, these have uniformly proved to be, at the best, palliatives only and the temporary easement has quickly reverted to even worse conditions.

These attempts have taken the form of regrading the junior staff positions. As an example, in July 1960, the Assistant Engineer/Engineer grade was improved from a starting salary of R1,392 per annum rising to a salary of R2,700 per annum within ten years to a commencing salary of R1,560 per annum reaching a salary of R3,000 per annum within eight years; within a few months the department was up to establishment, for the first time in over ten years. This happy state of affairs lasted for a few bare months only and the position is now as acute as it has ever been. This is in spite of a further improvement to the salaries some eighteen months ago.

The general pattern shows that the shortage of professional staff is becoming more and more serious, and the palliative measures mentioned above, instead of improving the position, have the opposite effect. The problem is not, of course, peculiar to Johannesburg, but is a national one, and the increasing tempo of constructional work throughout the country, for example

the National/...

the National Road Scheme and the Orange River Scheme (R450,000,000), can only tend to make an already serious problem critical. The effects of these new national schemes are no mere supposition; for example, the Council has in the past received applications, and employed from 5 to 17 graduates from the Witwatersrand University each year. This year - 1963 - of a class of 24, only one newly qualified engineer joined the department, and this lone young man is a Council pupil who has completed his pupilage and is obliged to serve the Council for two years.

The bulk of the new graduates have joined consulting engineers concerned with such schemes as mentioned above, mostly at starting salaries superior to those offered by the Council, and with the offer of better prospects. It is in the latter question, that of prospects, that the attraction of the very interesting work offered by the department turns sour. Young engineers can see that once they have reached the top of the engineer grade, which takes about eight years, future progress will be by slow steps, each associated with greatly added responsibility, a demand for much more sophisticated techniques, and a negligible increase in emoluments. This question is discussed in some detail at a later stage in this memorandum.

It has often been suggested that one short-term solution to the department's problem is to reduce the staff in size and employ consulting engineers to perform the essential civil engineering work. This policy has been tried but has not been successful, and though the department has appointed consultants to undertake the design of roads, stormwater and sewerage reticulation projects, it has been found that while this has released junior staff for other urgent work, senior staff has, if anything, been required to devote more time to supervision and liaison with the consultant. As the shortage of engineers is fairly general, it inevitably gives rise to a strong tendency for consulting engineers to attract staff, particularly the junior ranks, away from the department by financial inducement.

The result is a vicious circle, as handing out work to consultants who have already got their plates full, directly or indirectly leads to a flow of staff away from the Local Authority to the consultant. Of the last 20 engineers who have resigned from the department, 12 have gone to consulting engineers. This is a case of the remedy being far more serious in its results than the disease it seeks to cure.

Cost comparisons of design works carried out departmentally or by consultants are easily made. The consultant charges standard fees as laid down by the South African Association of Consulting Engineers. These fees

have/...

have been selected to cover direct engineer costs, office overheads, senior engineer supervision and consultant's profit. It has been found that design costs of projects carried out by the Council are uniformly lower than is the case when the works are prepared by consultants.

The question of the quality of the design work is of importance. It has been the experience in the department that apart from the employment of specialised consultants for the design of some specialised structures or works, designs carried out by the department's own staff are usually superior to those carried out by consultants. This is by no means intended to decry the standard of our consulting engineers, but is due to the superiority in experience and local knowledge which are the peculiar virtues of the Council's engineer.

The question of intimate knowledge in detail, of the city, its existing services and development trends, is obvious and needs no elaboration, as the Council's engineer is obviously in a much better position than is the consultant.

Specialised experience, however, is another matter, which at least to the lay eye, is not so obvious.

Civil Engineers in the Council, for example, have the opportunity of, and do, obtain first hand experience in the operation of the sewer system and sewage purification works. This practical experience is of inestimable advantage when new designs are to be prepared or problems solved. The engineers in the department are in this regard the envy of their fellows employed by consultants, and the latter are very conscious of the disability from which they suffer in design due to their lack of operating experience.

Specialist Consultants, particularly in the field of structural engineering, can however make a very real contribution. Elevated motorway construction, for example, is one operation which could well benefit from the specialised knowledge and techniques of some consultants if it is possible to award contracts on a design and construct basis. The possibilities are being explored but it is a sine qua non of this system of tendering that high level supervision and checking of designs is provided. Highly skilled experienced engineers are necessary for this work and the department has fortunately still a few men of this class in its service.

As has been mentioned earlier, the shortage of engineers is a national problem and there have been interesting developments in the engineering world to cope with the crisis. The most significant development

has been/...

has been the evolution of a new group of men, the engineering technician, or aide, as he is sometimes called. In the past, members of this group have come in the main from three sources:-

(i) draughtsmen;
(ii) unqualified surveyors (mainly ex mining surveyor trainees);
(iii) unsuccessful engineering students.

These aides have proved an invaluable asset to this department and have been able to do useful work in restricted fields under the direction of the qualified engineer. The group has proved so valuable in the department and other engineering organisations where they are employed that they have become accepted as an essential part of the organisation. Courses have been arranged and are now commencing at the Technical Colleges, so that young men may be, in future, specifically trained for this purpose. The courses envisaged lead to the award of a Civil Engineering Technician's Diploma, which is recognised by the State.

The technician cannot, however, directly relieve the shortage and replace qualified engineers, though he can relieve them of some of their more mundane functions and thus permit them to work at higher levels, and consequently, at a higher productivity. The aide or technician can in this context be regarded as an extra pair of hands for the engineer.

The employment of members of this group will consequently be of great assistance to the department in its efforts to realise the maximum efficiency from its technical staff.

In brief, the base of the pyramid of the technical organisation should be filled with engineering technicians while the higher positions only should be filled by engineers, each working at as high a level as possible.

These means will promote efficiency and the aim must be for each expert to be given the opportunity to realise his full potential. This is never possible where trained professionals are required to work at levels below their capacities.

The conclusion to be reached is that there is no way out for the department but to augment its engineering staff, and this with the highest trained and best quality men available. The employment of specialist consultants and engineering technicians is also a necessary step to supplement and complement the activities of the department's engineers.

DEPARTMENTAL/...

DEPARTMENTAL ORGANISATION:

The part played by the Civil Engineer in the growth and economy of the city has been described in some detail. It remains to consider how best the department can be re-organised to perform this function.

Much has been said in the past of the responsibilities of the Engineer and it is perhaps advisable to recapitulate at this stage how these differ from those of his colleagues.

Firstly, there is the responsibility for life. Large projects, unfortunately, do exact a toll of life from the workers, as frequent reports in the daily press of fatal accidents during construction testify. These are often followed by criminal prosecution of the responsible engineer if his competence or diligence are in question. These unhappy cases serve to illustrate one of the inherent problems presented in engineering practice, that is, the balancing of the cost of safety measures in both time and money against the possible consequences of injury or death to the workmen. Over conservative decisions may avoid some accidents, but only by an unnecessary direct increase in the cost of the work.

The second responsibility is what is embraced by the term "efficiency". A conservative design, or method of construction, will often meet the bill as far as the client, that is the City, is concerned in that the cost appears reasonable and the finished work performs its designed function. On the other hand, an imaginative design or the adoption of newer more sophisticated methods of construction, might well result in a better job which performs the original function more efficiently being obtained at a lower cost. In works, totalling R9,000,000 per annum, a saving of 10% arising from high standard designs can, be it noted, mean a saving of R90,000 per annum. In short, an engineer's mistakes cost money and his successes save money.

It will be appreciated that this is a somewhat simplified picture, and that the enormous gains to be obtained by the City as a result of the preparation of the highest standard of imaginative designs cannot be readily evaluated in Rands and cents. Suffice it to say that the prosperity of the City and its people of tomorrow is dependent on the degree of success achieved by its engineers and planners of today.

Reflection on the points mentioned makes it very clear that the professional engineer must fulfil a function which cannot be evaluated by comparison with his fellow Council employees, whatever profession or occupation they might follow.

This is/...

This is not an attempt to deny the value of the service performed by these other officials or to minimise the fact that their duties and responsibilities may well have grown with the passing of the years and the increase in size of the City. It is essential, however, to emphasise the peculiar role that is being played, and must be played, by the professional staff of this department. (APPENDIX A).

Professor Buchanan in his recent report on 'Traffic and Towns' prepared on behalf of the British Ministry of Transport, has very aptly described the position when, speaking of the need for traffic planning, he has said that the costs of schemes for the future are astronomical, but the country (Britain) has no alternative but to face them, or the result will be complete strangulation of the economy and deterioration of the environment. The report adds a further warning - "Today is almost too late"; we cannot wait till tomorrow.

These significant words apply to the problem of city development everywhere, and as has been said, the prosperity of our City in thirty years' time will depend on plans which must be produced now. We, too, cannot wait until tomorrow. (APPENDIX B).

This then sets out the challenge the modern city makes to its engineers; a challenge, incidentally, which the officials are only too ready and willing to take up. Though the spirit is willing, the flesh is, unhappily, woefully weak; with the present structure of administration and organisation the engineers, however willing, cannot hope to make the success of the job that the occasion demands. The reason is, not unexpectedly, that the organisation built up to meet the conditions of yester year, is not suited or sufficiently adaptable to the modern demand.

Basically the re-organisation required is the delegation of more responsibilities to the more senior men and the formation of a 'forward planning' group; the latter being a high level group of engineers, town planners, architects and others working in close relation to other branches but with complete relief from routine burdens. This group will prepare the plans for the future in broad outline, leaving the details to be filled in when required, but making it certain that when detailed designs for various projects are prepared, they will fit in perfectly with the overall plan. Inevitably planning cannot be circumscribed by the bounds of the specific fields for which the department is directly responsible, nor can it stop at the municipal boundaries. This planning group must to a large extent be the

planning/...

planning body for the whole of the Council's service and it is unthinkable that it should endeavour to plan without, for example, close co-operation with the Transport Department in matters of town planning and transportation planning, or that it would plan for future abattoirs or markets without the close co-operation of the senior officials of the department concerned.

The responsible Council committees would no doubt welcome the formation of such a group which can ensure that when, for example, a new market is mooted, it is not a case of a decision being made by one or even two departments after consultation, but that the whole project is examined in toto against the broad background of future plans for the city.

This is the major problem of re-organisation. It is considered so important, and time is so limited, that the first step has already been taken by the release from administrative duties for 'forward planning' of a senior traffic engineer and town planner.

The full implementation of the re-organisation depends, however, on two factors:-

(i) Quality of staff.

(ii) Numbers of staff.

As far as the quality is concerned, there is fortunately little cause for complaint. The department is fortunate in having the services of highly qualified and competent men who have devoted their energies to the benefit of the City and, moreover, who have the capacity and time to read and study contemporary technical literature to keep themselves fully abreast with modern thought and methods.

The position is partly as a result of the more attractive prospects afforded by the salary structure in the past and partly because of the 'nature of the beast', that is, there are always some altruistically inclined individuals who feel that they can find in the City's services the opportunity for due fulfilment of their desires to do a worthwhile job during their working lives.

The department numbers among its staff many such persons who feel that the job is bigger than its creator. It is essential that the services of these men is retained.

The numbers of the staff, however, is a matter of the gravest concern. The best quality graduates are now finding fulfilment in other fields, and it is a long time since the department has been able to pick the cream of the new graduates.

The frustrating/...

The frustrating position has now been reached where senior experienced and highly qualified engineers are compelled to carry out uncomplicated investigations and designs - low level work - purely because of the lack of young graduates and experienced technicians. The department has senior men capable of the highest quality work, an urgent need for the work to be done, and a total inability to release them from mundane low level work because of the short-term expendiency of work of this nature.

The position is exemplified by the figures. There was a 30% turnover in engineering staff of the Planning Branch - the engineer pool - during the past year and the department has presently 27 vacancies out of the 62 positions on the establishment of this branch.

This is the major problem to be solved, and logically, therefore, the department must:-

(i) Increase the number of technical aides.

(ii) Retain in the service, and increase the number, of experienced senior engineers.

(iii) Increase the number of first rank young engineers who will be the seniors of tomorrow.

(iv) Make fullest possible use of suitable outside agencies.

Points (i), (ii) and (iii) are to a certain extent interrelated in so far as the employment of a sufficient number of technical aides is dependent on the remuneration offered. The present recently amended grade is reasonably attractive to the young aide, but once his experience makes him useful, that is after seven or eight years at the most, he can obtain a far more attractive salary in outside bodies. The maximum salary to which he can aspire in the Council's service is now R2,832 per annum, and though an experienced man with many years experience is worth a great deal more than this figure to the department, extension of the grade cannot be recommended without seriously overlapping the professional engineer grades.

Herein lies the root of the trouble; the engineer grades and, in particular, the prospects of progression.

The department is organised, on the ascending scale, as follows:-

(i) <u>An Entrance Grade of Assistant Engineer/Engineer</u>:
Progression through this grade is dependent purely on application and ability.

(ii)/...

(ii) A Principal Engineer Grade:
Promotion to this grade depends not only on competence, but also on there being vacancies on the grade.

(iii) Assistant Branch Heads and Branch Heads:
Promotion to these positions is, once again, dependent on vacancies.

(iv) Departmental Head and Sub-heads:
Again, promotion is dependent on vacancies.

It is inevitable that the more senior positions should be restricted in number. This is the position common to any organisation where the structure of the group is in the form of a pyramid with only one position at the top and a progressively increasing number in the descending layers.

There can be no objection to such an organisation in itself. To be attractive and effective, however, the rewards must be commensurate with the degree of rivalry and competition, and engineers who are successful in progressing from one stratum to the next must find an adequate increase in remuneration commensurate with the elevation in responsibility. Quite clearly, if the progressive steps are not marked by a clear and substantial reward, there is likely to be little interest in advancement or incentive to achieve what is in effect a nominal promotion.

In the past the financial pyramid faithfully duplicated the organisational pyramid. Steps in both were distinct and well marked. In 1939, for example, the commencing salary of engineers was R30 per month (£15). The salary of the top man - the City Engineer - was R500 (£250); a ratio of 1:16.7. The respective figures are now R194 and R700, a ratio of only 1:3.6; and this notwithstanding the increase in size of the department, its vastly broader scope and the tremendous overall responsibility now placed on the City Engineer. A direct comparison in the head of the department's salary is illuminating. This has increased from R6,000 (£3,000) in 1939 to the present figure of R8,400, which represents a marked decrease in emolument if even conservative allowance is made for the relative purchasing powers of the Rand.

This unfortunate position has arisen as a direct result of the Council's attempts to overcome its staff deficiencies. The solution adopted, which has also been commonly used by other organisations, has been to regrade

the entrance/...

the entrance grade, that of the Assistant Engineer/Engineer, to make the commencing salary as attractive as possible, while making minimal adjustments to the higher grades. Several progressive regradings have telescoped the 'financial pyramid' until instead of resembling a step pyramid it is now a flat indeterminate figure.

This policy has enjoyed only some short-term success and has otherwise proved a failure. The impossible position has now been reached in some smaller local authorities on the Reef where the new fledged graduate is offered R3,000 or more per annum; the corresponding figure in Johannesburg is R2,328. There is no point in pursuing this policy further, as it can, at best, if the grade is favourable in comparison with those pertaining along the Reef, result in the temporary attraction of some new graduates. It cannot serve to retain or attract experienced men and has in fact been found to lead to their dissatisfaction more than anything else.

This problem of the telescoping of the salary gradient is not peculiar to Johannesburg and its City Engineer's Department. It occurs elsewhere and has been studied carefully by experts and has even given rise to a new science - the science of emolumetrics.

A paper on this subject recently presented to the South African Institution of Civil Engineers (APPENDICES C AND D) very clearly outlines the problem and goes a long way to explaining why the past policy, with its inevitable effect of telescoping the ladder of progression, has been doomed to failure. The author of this paper emphasises that it is essential to maintain, at all times, a satisfactory rate of salary growth. This is represented in the language of emolumetrics as an 'income gradient'. When represented graphically this gradient should be about 0.6. If it falls below 0.5 for any professional group, then a shortage of members of the group can be expected.

A graphical representation presented by the author of the abovementioned paper has been reproduced in part (GRAPH NO. 1). This shows the curves for Attorneys and Doctors and that for the average tax payer (1955). Curves have been added to reflect the income gradient for the department's engineers in 1946 and in 1962. A further curve, for comparison, shows the 1946 curve corrected for the depreciation in value of currency over the period (a factor of 1.6).

This provides an excellent illustration of the position. The gradient of 0.5 of 1946 has fallen in 1962 to 0.21.

This is the reason for the department's troubles. There is, in effect, very little incentive for professional engineers to pursue their

careers/...

careers in the Council's service. They can look forward to a high rate of progression as far as responsibility is concerned and a low rate of progression financially.

To take a broader view, the influence this has on potential university students must be borne in mind. A very small proportion of the first rate material entering the universities will be attracted to the courses of the engineering faculty, which are acknowledged to be difficult, when the ultimate rewards are manifestly so meagre.

CONCLUSION:

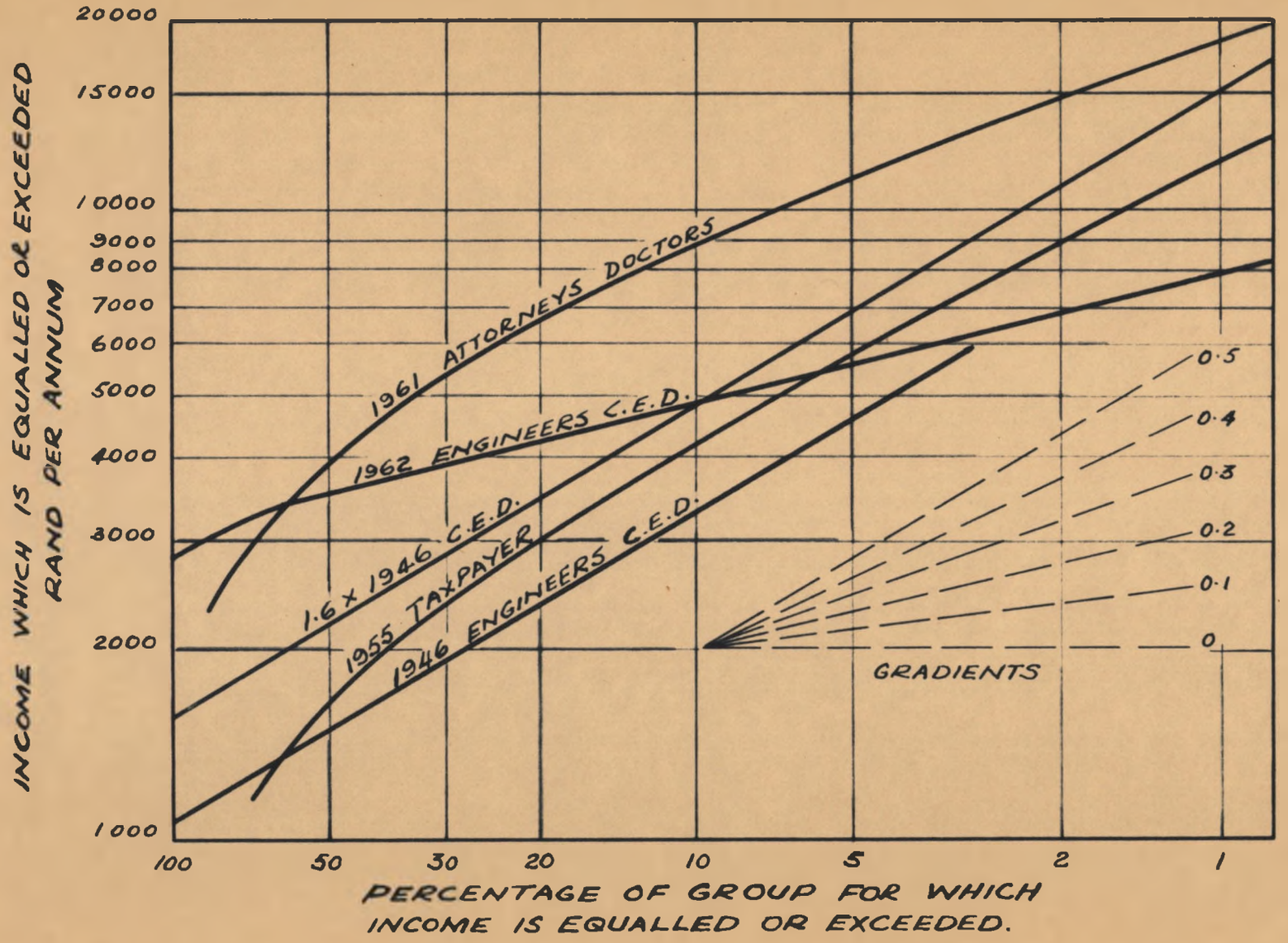
The purpose of this report is to emphasise the vital role played by the City Engineer's Department in the future welfare of the City. To meet the demands, the department must attract, and retain, the best brains in the profession and in the country, and what is more, an adequate number of these men.

The use of second rate material will inevitably result in second rate solutions to our problems and hence a second rate City in the future.

By good fortune the department has some of the first rate material, inadequate though the numbers may be.

These men must be retained and their numbers augmented. It is unthinkable that anything less than the best available should be good enough.

The solution is to reconstitute the financial pyramid and regrade the positions drastically from the top down. (APPENDIX E).


INCOME WHICH IS EQUALLED OR EXCEEDED
RAND PER ANNUM
20000
15000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
1961 ATTORNEYS DOCTORS
1962 ENGINEERS C.E.D.
1.6 x 1946 C.E.D.
1955 TAXPAYER
1946 ENGINEERS C.E.D.
0·5
0·4
0·3
0·2
0·1
0
GRADIENTS
100
50
30
20
10
5
2
1
PERCENTAGE OF GROUP FOR WHICH
INCOME IS EQUALLED OR EXCEEDED.

GRAPH NO. 1

APPENDIX A.

PROFESSIONAL SALARIES FOR PROFESSIONAL MEN.

There was a time when a limited programme of works supported the illusion that there was sufficient manpower in the technical professions to cope with redevelopment schemes, general development work and the provision of new transport facilities when these projects became necessary. The last ten years has seen a major surge in work of this kind, and with new building work in progress in most towns the inertia forced on us by the war has at last been overcome. Bombed sites, which have stood idle, providing wild gardens for countryside flowers amidst the bustle of city life, are beginning to disappear, and old tenements and terraces are giving way to new buildings with a strident effect due to the startling contrast they make with their surroundings. With this development in existing towns has come the birth of new towns and the beginnings of a country-wide system of motorways.

The result of all this activity, which has attracted investment on a scale without precedent in this century, has been to put a heavy, if welcome, load on the technical professions. The services of planners, architects and engineers are now in considerable demand, and the creation of new firms and departments and the rapid expansion of existing organisations have turned the relatively easy advertisement for staff into a competition for candidates. The use of large 'glossy' advertisements in place of the small discreet notice has been a feature of the last few years. National papers carry large spreads with pictures and off-beat drawings and diagrams to attract the eye, and in spite of claims that salaries do not bear comparison with industry and commerce, there has been a steady upward trend for some time.

Improved facilities for education, following a long way behind the national need, have not turned out the extra numbers of professional men required. Keen competition from the scientific, industrial and commercial fields has also restricted the profession's share of the available manpower. On top of this, as emphasised by the Fellden Report in the sphere of mechanical engineering, best use is not being made of what is available, and an unbalanced pay structure, far from keeping men on the technical side, forces them to move into the more highly paid administrative posts at the earliest opportunity.

Local government is not organised to act successfully in this competition. The national salary scales, which were a major and satisfactory step forward at the time of their institution, seem to be accepted by the employers as an unchangeable basis for many years to come. From lettered scales downwards the horizontal relationship at all levels between the different departments results in a virtual stop to the natural action of supply and demand. While special scales for qualified staff made a brief appearance, the feeling that the technical professions cannot be given special treatment has not been overcome. If assistant engineers are upgraded then obviously administrative staff have to go up too. Local authorities' large salary bills have a direct effect on the rates, and all-round increases are naturally unpopular. An unfortunate outcome of this position has been the adoption of various practices to get salary increases for technical staff 'under the counter'. The most undesirable of these has been the appointment of unqualified men to posts in the middle range of seniority. Many of these men are admirable members of their departments and some, with a more practical than theoretical approach whose ability warrants promotion, barred by the national scheme, have got by the barrier in this way. The overcoming of short-term difficulties by this means presents serious problems for the future when senior appointments become vacant, does nothing to stimulate a will to work hard for qualification and undermines the

professions/...

professions as a whole. The breadth and depth of mind needed to attain professional status may not be essential to the carrying out of minor projects, but it is desirable in those concerned with the execution of major schemes and essential in the man at the head of an important section or a department. The employment of too many unqualified men must have its effect on individual offices and entire professions, and current criticisms of the lack of imagination shown in many projects, and evidence of an unwillingness to leave old ways behind and to strike out in an effort to find new solutions can be traced back, in part at least, to this tendency to lower professional standards. The technical professions have been taking steps in the last few years to raise standards of entry, and it would be sad to see the effectiveness of this action reduced by an extension of the practice of employing unqualified men.

After some misunderstanding among juniors in the early stages it is now generally accepted that chief officers' salaries stand at the head of the pay problem. If a chief is paid a fixed sum by the usual operation of nationally agreed minima as local maxima, then it will not be long before the gradual climb of staff salaries, forced up by shortages, is brought to a halt when it catches up with the deputy paid on a two-thirds basis. There are cases in the smaller authorities where senior staff are paid the same as their chief, but this is rightly out of favour with employers and is unlikely to become widespread. By being unwilling to make radical improvements to the amounts paid, the generally satisfactory solution of linking salaries to population is placed in jeopardy. If individuals have just complaints that the system works against them, the remedy of higher payment is in the employers' hands. While sticking to the population basis, which provides a practical solution to a very difficult problem, not slavishly but as a general framework, and by adopting a realistic level of remuneration in the light of comparable work in industry, commerce and private practice, the whole picture could be changed overnight. Instead of avoiding local government, or taking every opportunity to leave it, members of the technical professions would be able to make worthwhile careers in the Service. It is all very well to talk of vocation from a well paid commercial chair, but only a down to earth approach on salaries will get and keep a proper share of the best brains.

The freedom to manoeuvre which this sort of adjustment to chief officers' pay would bring must be used to attract and retain high calibre junior staff. Though improvements to the salary of administrative staff have been necessary in the past, there is no reason why they should be maintained on the level of professional pay. The role of supporting clerical staff cannot possibly claim equality with professional work. Along with much else in the municipal field there is a crying need for rethinking of the salary structure, and local government re-organisation proposals give an opportunity for relatively painless implementation of the radical changes required.

EDITORIAL: "THE SURVEYOR AND MUNICIPAL ENGINEER"
Vol. CXXII No. 3720, 21st September 1963

APPENDIX B.

EXTRACT FROM "THE SURVEYOR AND MUNICIPAL ENGINEER"

Editorial: Vol. CXXII No. 3732, 14th December 1963.

We have now reached a point when, in an atmosphere of expansion, the demands on the technical professions have reached an intensity quite beyond post-war experience. Once it was a case of the private sector being very quiet, with bombed sites all over the country lying dormant year after year, and professional men in the public sector preparing schemes for which it seemed there was never any money: now one can honestly say a new spirit is abroad, and the difficulty immediately is to find the technical staff. Not only is there a serious need to use professional staff more efficiently, which is a matter for the chartered institutions - there is also a need for proper standards of pay, so that the financial yardstick which we use with very practical success in our society, will not show that local government is getting short measure. When 'an arch apostle of private enterprise', as Mr. L.S. Marler described himself at the People and Cities Conference, says 'it is becoming absolutely essential for Public Authority to take action', then maybe the penny has at last dropped. It does not require much familiarity with them to realise that if public authorities are to take action in today's circumstances they will need the very highest standard of professional staff they can get.

High quality means high salary. If, every time the technical professions make the case for a pay rise the rest of the local authority staff get it as well, what prospect is there of ever reaching an appropriate level? No suggestion is intended here that the mass of local government employees should be underpaid. They deserve just payment for the responsibilities they carry, in fair comparison with other organisations. The point is the need for proper payment of the technical professions whose responsibilities command considerably higher salaries. The employers cannot be blamed for turning down the technical professions' claims when they know the result will mean a general rise for all the staff. Nalgo cannot be expected to favour a small minority of its membership, and the annual or a special conference would soon put paid to any move in this direction. By sticking to outmoded arrangements and submerging their interests in those of the mass of clerical and supporting staff, the professions are serving more than themselves ill. The vigour and effectiveness of local government depend upon the quality of the professional staff, and the hard fact that higher quality attracts higher salary must be faced.

APPENDIX C.

SALARIES AND STATUS OF ENGINEERS SHOULD BE RAISED

That engineering salaries should be increased two- or three-fold and that the status of the engineer should be raised, were recommendations made by speakers at the Diamond Jubilee Convention of the South African Institution of Civil Engineers in Johannesburg. Other speakers said that local bridges were being heavily over-designed and urged that a thorough investigation be undertaken to establish realistic loading conditions.

"PROFESSIONAL SALARIES SHOULD BE INCREASED to double and treble the present figure" was a recommendation made by Mr. K.A.H. Adams, a partner in the firm of consulting engineers, Adams, Symes & Partners, in his paper entitled "Emolumetrics and Engineering" presented at the Diamond Jubilee Convention of The South African Institution of Civil Engineers recently held in Johannesburg.

Both Mr. Adams and Dr. S.S. Morris, the City Engineer of Cape Town, maintained that the civil engineer, in many instances is underpaid and often regarded as a "glorified artisan" rather than an important and highly responsible member of the community. Emphasis was given by Dr. Morris to the continually increasing responsibilities of the civil engineer in local government and the approach required to meet these responsibilities successfully, while Mr. Adams pointed out that only small expenditures of money by Public Service and employers would be required to increase senior salaries, the sociological and economic benefits of which would be great. Mr. Adams went on to say that if the present trend in raising starting salaries and flattening the income gradient continued, the youth of the country would be discouraged from entering the field of engineering.

Dr. Morris urged engineers to take a greater interest in matters of management and to expand their horizons in cultural matters.

"The need for efficient management and administration in local government, as well as in any other organisation, is so self-evident that it requires no special emphasis", he said. "And yet it is surprising how many engineers still view management with suspicion, if not complete antagonism. Indeed, to a number of engineers, management is an objectionable if not an obscene word! To these individuals, still tethered by professional apron strings to either the calculation sheet or drawing board, decisions reached other than by slide rule or calculus are untenable. Technologically blinkered, atrophied by intellectual agoraphobia, they remain bound in the strait-jacket of narrow, specialised, professional isolationism. To these engineering iconoclasts, economics, art, literature, philosophy, sociology, politics and history and all their kindred treasures are distasteful and inferior foreign fields, to be entered only at peril, and preferably to be avoided.

"Every engineer on any reasonably sized construction job appreciates only too well the importance of careful pre-planning and programming of the various tasks involved, and of applying effective management control such as costing and progress reporting to ensure that planning is properly implemented", Dr. Morris went on. "The scale and complexity of modern projects and of the

"mechanised/...

"mechanised equipment and plant now used instead of the hand labour that formerly dominated construction activities, make planning and management control even more important nowadays than they used to be. The disciplines used to achieve efficiency in construction yield no less important dividends when applied to other aspects of the engineer's work, not only in design and administration, but also in policy making.

"Too many engineers become so engrossed in the purely technological aspects of their activities that they are inclined to neglect the managerial, administrative and policy-making facets of their over-all function", Dr. Morris continued. "With so limited a vision of his own responsibilities, it is hardly surprising that an impression is created of the engineer as merely a glorified artisan. Limited professional horizons do not encourage enhanced status.

"In the end it is not only the engineer himself who suffers. If the image of the engineer is that of only a professional introvert, an expert to be on tap rather than on top, the public as a whole will suffer. Certainly, the ability of local government to cope with South Africa's rapidly increasing urbanisation and industrial awakening will be severely inhibited. Ultimately the national economy must inevitably suffer.

"The search for technical perfection is a laudable pursuit, but the civil engineer's fundamental objective must go further than this praiseworthy purpose.

"For their part, civil engineers must show that they are competent to assume the heavy responsibilities which will devolve upon them. They must show that they are not merely narrow, function-dominated specialists, but also men of vision and sensitivity; men dedicated not only to conquering the forces of Nature but also to serving their fellow men".

The theory of emolumetrics was described and explained by Mr. Adams in his paper and he used the accompanying graph to illustrate the relative income groups within a community.

"At the beginning of a career, it will be seen that the incomes rise steeply", Mr. Adams said. "After that the rise is less pronounced and remains relatively constant as the higher incomes are approached. It is in this region that the income gradient is measured. If there is need to distinguish it from gradients measured elsewhere on the curve, reference is made to the dominant income gradient.

"It will be noted that the curves for the three employee groups have relatively low dominant gradients. Numerical values are approximately:-

Male high school teachers	.09
Artisan fitters and turners	.10
Engineers	.12

"The curves for the accountants, attorneys, doctors and bookkeepers are typical of self-employed groups of persons. The dominant income gradients are in the order of 0.5 and are several times those of the employee groups.

"The gradient applicable to the largest group of activity in the country - i.e. the whole population - is given by the curve for the taxpayer. It will be noted that the gradient is in the order of 0.5 and has been consistently so for the country since 1920. This consistency is universally

"observed/...

"observed and gradients in the order of 0.45 to 0.7 occur. A calculated 'natural' value is 0.618.

"The relatively poor gradients in employee groups are certainly anomalous. Those in which conditions are notoriously bad are those with the lowest gradients. The fact that employees have apparently greater security in employment than self-employed persons does not account for the extreme difference in treatment as far as gradient is concerned. The apparent difference in security may permit an elevated level for the earnings of non-employees, but no argument yet postulated can justify a gradient for employees less than perhaps two-thirds or one-half that of the non-employee.

"In relation to the raising of the income gradient", Mr. Adams went on, "the employer often claims that the incomes are regulated by the law of supply and demand. There is never a shortage of senior personnel and therefore the emoluments paid at these levels are satisfactory and need not be changed according to some arbitrary reasoning.

"But", he said, "this condition must be faced. The first requirement for any induced change in gradient is that those in senior positions must want to earn higher salaries. Having shown, in the light of the study of emolumetrics, that the earning of higher salaries by senior personnel will bring sociological and economic benefits, it remains only to say those senior personnel who wish their salaries to remain at a low level are measuring their competences realistically. If such persons head large groups of engineers, for example, then they may well be stifling the advancement of individuals within these groups - and reducing the value of their output of work. Only pressure from group members on their leaders can alter the attitude of the leaders towards earning appropriate incomes.

"The employer, however, is not quite correct in his analysis of the situation. The salaries paid to senior personnel are not so much related to those which are accepted, but more so to the necessity of attracting suitable successors. If the quality or quantity of apprentices falls off, for example, the fault may well lie in the wages of the foreman being too low.

"Presumably the employer will always have a vested interest in the quality of his staff. If so, it is essential that he realises that he can apply corrective action, to his own advantage, by paying senior personnel greater emoluments than they demand - or greater even than they are prepared to accept.

"Those who remain for a long time in a flatly-graded group will, in general, place a high value on the attainment of security, having already found that progress will bring little reward", Mr. Adams went on. "To these persons, their past will be more important than their future. This latter condition would also apply to a group of persons on the point of death. Life essentially implies a future more important than the past.

"If the controlling authority of a professional society consists of members with an oversize vested interest in the past, then it can damage the profession it represents - and damage it irreparably. Professor Parkinson has dealt with the parallel case of organisations in which injelitance has set in. The condition is characterised by smugness, complacency and selfsatisfaction on the part of the controlling authority and

"senior/...

"senior staff, followed by a general deterioration of the whole organisation. The attitude of such organisations would be that continued existence should be allowed because of their past.

"There is no doubt that the engineer's position in the Republic, and elsewhere, has been seriously affected by this interest in security on the part of the controlling authorities of his professional societies. But security cannot be achieved in this way. The Romans had no illusion about security. Si vis pacem, para bellum, i.e. if you seek peace, prepare for war.

"It may be difficult, even impossible, for the controlling authorities of the professional societies to drop their inferiority complex and direct their energies towards providing the second service for its membership. This is to provide means whereby the progress of any of its members in his profession can be manifested. Progress must be recognised and it should not induce jealousy in any form. When this is done, the status of the engineer will be on the way up and his security ensured".

CONSTRUCTION IN SOUTHERN AFRICA, November 1963

APPENDIX D.

A Letter to the Editor

ENGINEER'S PAY INCREASE NOT COSTLY

The introduction to an article which we published in the November 1963 issue of Construction in Southern Africa, entitled "Salaries and Status of Engineers Should be Raised", may have led to some misunderstanding of the recommendations made by Mr. K.A.H. Adams in his paper delivered at the recently held Diamond Jubilee Convention of the South African Institution of Civil Engineers. Mr. Adams has written the following letter to clarify the issue and puts his recommendation in a nutshell:-

The Editor,
Construction in Southern Africa.

Dear Sir,

Your article commencing on page 35 of the November, 1963 issue of Construction in Southern Africa deserves praise and commendation.

Your introduction, "Professional salaries should be increased to double and treble the present figure", attributed to me, might, however, mislead a large portion of your readership.

The intended theme I wished to convey was that salaries of the most senior members of the engineering profession should be raised to at least two to three times their present level. The entry salaries should remain substantially the same: intermediate salaries should be proportionately increased.

The net result will be a greater inequality of salaries in the engineering profession: or, in other words, a steeper income gradient will exist in the engineering profession. It is this steeper income gradient that increases the importance and value of the engineer's work in the community, and enhances his status. The mere raising of all engineers' salaries to two or three times the present figure will not achieve anything permanently.

I am perturbed that employers will gather from your introduction that their salary bill for engineers will be increased by 100% or 200% if they implement my proposals. In fact, the cost of increasing the income gradient to give tremendous advantage for both the employer and employee requires an extra 5% to 15% over an existing salary bill - a comparatively trifling amount.

Several months ago, a large engineering group implemented this approach. The results were impressively encouraging and followed the theoretical predictions closely.

While your further quotations from my paper help to counteract the impression gained from your introduction, I would like to suggest that you comment on this point in a subsequent issue.

May I again compliment you on this article?

KENNETH ADAMS
Adams, Symes & Partners
Johannesburg

CONSTRUCTION IN SOUTHERN AFRICA, January 1964

APPENDIX E.

HIGHER STATUS AND PAY IS THE ANSWER

Higher status and pay could overcome the critical shortage of qualified engineers in South Africa, Mr. A. Roberts, President of the Institution of Civil Engineers told the Southern Transvaal Region of the South African Road Federation in Johannesburg.

The status of engineers was not as high as it should be and they were badly paid compared with other professions and could generally not reach top posts in their departments whether in the Government, Provincial or Municipal Service.

BUSINESS NEWS, November 1963

APPENDIX F.

NEW SOLUTION TO DETERMINE ENGINEERS' SALARY SCALES?

A possible solution to the anomalies which appear to be a permanent and integral part of the local government salary structure can be found in an article in the current PROFESSIONAL ENGINEER - the journal of the Engineers' Guild.

In the article, A logical approach to the subject of wages and salaries, Dr. R.H. Grundy suggests that the salaries for engineers on intermediate grades should be equal to the chief engineer's salary divided by the square root of the number of people responsible.

The latter factor is derived from the number of assistants on any specific plane of responsibility plus those in the plane immediately above it. It is thus assumed that two successive grades carry the responsibility between them.

Four Section-Heads

If there are four section-heads under the immediate control of a chief engineering assistant, and the chief officer earns £5,000 per annum, the salary for each of the former would be £5,000 divided by the square root of five, i.e. approximately £2,240 per annum.

Again if the four section-heads in the same department each had two senior assistants working for him, the appropriate salary for the latter would be £5,000 divided by the square root of 12, i.e. approximately £1,450 per annum.

Quite obviously this would leave little scope for the lower grades, and it is evident that the chief's salary in our hypothetical set-up is not quite high enough.

Sticking to the same example, the deputy would receive £5,000 divided by the square root of two (i.e. approx. £3,500). However, Dr. Grundy suggests a further emolument if the post involves complete responsibility for the department in the chief's absence.

The salary for the chief engineering assistant would appear to depend in this case on the lines of communication, and the divisor could be either $\sqrt{3}$ or $\sqrt{4}$. Dr. Grundy indicates the latter in his example since his department has three engineers ranking third in the hierarchy.

Incidentally the salaries referred to are maximum salaries throughout. It is suggested that the starting salaries should be three-quarters of the maximum.

NEDC Factor

Dr. Grundy attempts to fix the chief officer's salary in relation to the principle that salary increases over an engineer's career (between the ages of 25 and 60) should follow a curve based on the 4 per cent pa NEDC productivity factor. It is assumed that the individual justifies a steady promotion.

He also/...

He also recognises that there must be a relationship at all levels between salaries and the number of workmen employed by the department. Alternatively the salaries could be related to total wages or to annual output of work.

In the example given in the paper the chief engineer earns a salary of £4,000 a year and is responsible for 250 workers each assumed to earn £800 a year. This is a lot better reward than he would receive in local government for the same responsibility. His staff comprises 16 engineers (including the deputy) on five salary scales and quite obviously there is little difficulty in applying the formula in these circumstances.

In local government, however, where an engineer earning £4,000 per annum might have 50 engineering staff, with half that number occupying the two lowest grades, the formula obviously would not allow even the current grade for a newly qualified engineer. But that is not Dr. Grundy's fault, nor does it in any way affect the validity of his formula.

From the above, however, a possible formula immediately suggests itself for the minimum salary for a chief engineer in local government, i.e. £1,400 (the August, 1963 maximum of APT IV) multiplied by the square root of the total number of qualified assistants at the two lowest levels of responsibility. Then if there are 25 of the latter, the chief's salary should be at least £7,000 pa.

On the other hand if he has only four assistants in this category, he should receive at least £2,800 and his deputy approximately £1,980 (i.e. £2,800 divided by $\sqrt{2}$). The latter represents an improvement on the sacrosanct two-thirds principle.

All this, of course, cuts completely across the present local government salary structure with its two separate ladders controlled by separate negotiating committees, each with its own vested interests. But then any real solution to the present difficulties must be revolutionary if it is to have any hope of permanent success.

For the suggested method to be practicable, departments must, of course, carry a proper numerical establishment of qualified engineers (with supporting staff). It is not thought that there will be many local authorities over-staffed for the work in hand, but there will be a few of the "one man and a boy" category even in this enlightened age.

Logical Chain of Duties

Also the suggested method pre-supposed a straightforward and logical chain of duties and responsibilities throughout the department. In other words the "tree" is a well-conditioned triangle with the chief at the apex.

Quite clearly if the department is lopsided with, say, a host of newly-qualified or about-to-be-qualified assistants and no experienced middle-men, Dr. Grundy's formula and its tentatively suggested corollary are quite unworkable.

Come what may, Dr. Grundy's paper should be read and digested by all concerned in salary negotiations, particularly in the field of municipal engineering where the need for a logical approach is now a matter of extreme urgency.

CONTRIBUTED

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