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The Congress as a body does not hold itself responsible for the opinions expressed in this volume.





The Hon'ble Mr. D. W. AIKMAN, C.I.E.,
Chief Engineer, Buildings and Roads Branch, P. W. D., Punjab
President (1917-18).

Punjab Engineering Congress

(ESTABLISHED 1912.)

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ADDRESS

OF

COLONEL S. L. CRA'STER,

PRESIDENT.

GENTLEMEN.—When considering what should be the subject of my address to the Congress this year, my thoughts, not unnaturally perhaps, busied themselves with a retrospect, for on 31st December last, the North-Western Railway completed thirty-one years of its existence, and my own service in the Railway Branch of the Department of Public Works, with which I must shortly sever my connection, corresponds roughly to this same period.

Again, the present moment is opportune to pause and think. Expenditure has been curtailed on account of the great war, and we, in common with the rest of the civilised world, stand on the brink of a fresh epoch, when victory shall have declared for those who have fought for right, freedom, and peace against might and world-wide oppression. Change is in the air, and so I trust you will bear with me if I sketch out, however inadequately, the engineering progress of this part of India during the thirty-one year period, 1886—1916.

In the course of my remarks, I cannot confine myself strictly to the Punjab, for the boundaries of the province itself have been changed, and Sind with its port of Karachi must, to a great extent, throw in its fortune with the Punjab, whose granaries and other commodities contribute so materially to the prosperity of the port.

On the other hand, Karachi, with its evergrowing facilities for dealing with the shipping which enters the harbour, enables the Punjab to reap the benefit of comparatively short communication with the sea, and the concomitant stimulus to imports from England, Europe and the Far East.

In the opening days of the period I have selected, men were in their prime who had helped to suppress the sepoy mutiny; men who had watched and perhaps taken part in the short but bitter struggle in the neighbourhood of Ambeyla in the autumn

of 1863, and in the Afghan War of 1878-80, and yet others who had seen the drought of 1868-69 in the east and south of the Punjab, which was succeeded by severe famine.

The necessity for improved communications by road and rail, for an ever increasing system of efficient canals, was generally acknowledged as among the tasks to which the energies of engineers should bend.

The needs of this province however, were many, whilst its wealth was potential rather than actual. Great had been the drain on the financial resources of India caused by the Afghan War, and to a lesser extent by various punitive expeditions against turbulent tribes on the frontier, and therefore the Punjab had to possess her soul in patience.

At that time, be it remembered, the whole Trans-Indus country, which now forms the North-West Frontier Province, was under the Punjab, and the Lieutenant-Governor of the province was in truth Warden of the Marches, with a mobile military force at his disposal for instant action should occasion require.

The Punjab Frontier Force had made its name, and at first comprised cavalry, infantry, light field artillery, garrison companies of artillery, sappers and miners, and a camel corps. The details of the composition changed as time went on, but the spirit remained, and their readiness to answer a call at any hour of the day or night was proverbial.

The great roads connecting Calcutta and Peshawar, and also those linking the forts, arsenals, and principal military stations of the Punjab with each other had been made, as also roads to Simla, Dalhousie, Murree and other hill stations, where troops passed the heat of summer. A military road had been built along the border, serving the forts and posts, and yet other roads towards far Tibet and the nearer Himalayan valleys such as Kangra ; but much remained to be done in the development of road communications, and it is interesting to note that of the twelve divisions of the Buildings and Roads Branch existent in January 1886, no less than five were Trans-Indus.

Whilst the trunk roads were substantially built over the greater part of their length, it had not been possible to provide permanent bridges over the Punjab rivers and the Indus, and I have no doubt that there are many Buildings and Roads officers at present in the service, who could tell us stories of the anxious times they have gone through in maintaining intact,

road communication over the boat bridges, come fair weather or foul, come flood or drought.

Good though the roads were, it was evident that railways must supplement them as main arteries of communication. The earliest of these built within the limits of this province was the section from Multan to Amritsar, designed (in conjunction with a steam flotilla from Multan to Kotri, and the Sind Railway from Kotri to Karachi) to obtain direct access to the sea. Begun in 1859, the section between Amritsar and Lahore was opened for traffic in 1862, and three years later that to Multan and Sher Shah, the river port of Multan. Ere this, connection with Delhi had been decided on, and was completed in the spring of 1870, when the Sind, Punjab and Delhi Company was formed to amalgamate the Sind Railway, the Punjab Railway and the Delhi Railway, under a Government guarantee of five per cent. interest. The weak link in the chain between Amritsar and Karachi was the river journey, for it took three weeks to accomplish the distance from Kotri to Sher Shah, when coming up stream. In 1878 this was superseded by the Indus Valley Railway, which ran from Multan to Rohri on the left bank of the river, and onward from Sukkur to Kotri on the right bank, passengers and wagons being ferried to and fro between Rohri and Sukkur.

Time does not admit to dilate on the difficulties encountered by the engineers who carried the line over the various rivers between Lahore and Delhi, but they won through, and the bridges over the Beas, the Sutlej, and the Jumna, which to-day carry the road instead of the railway, testify to the excellence of their work in the main, though there have been many fights with the turbulent rivers since those days long past.

Not content with the main railway artery just described, the Punjab Government, early in 1882, began the construction of the Amritsar Pathankot line under the supervision of officers of its Buildings and Roads Branch, and by the middle of 1884 this branch was feeding the main line with valuable commodities from Kangra, and the rich tract of country between Pathankot and Amritsar.

In the seventies the battle of the gauges was at its height, and, as a result, the trunk line north of Lahore, then known as the Punjab Northern State Railway, was ordered on the standard gauge, but was actually built from Lahore to Jhelum on the metre gauge, chiefly on the berm of the Grand Trunk Road. Almost as soon as it was opened it was given a separate alignment

and converted, and continued on the standard gauge to Peshawar, the complete length being opened in 1884.

Those who have travelled on the section above Lala Musa, before it was realigned and graded, can realise the magnitude of the task our predecessors successfully tackled.

This main line threw off branches north, and south, *viz.*, to Sialkot from Wazirabad, and from Lala Musa to Khewra, with a ferry, on this southern branch, over the Jhelum.

Lastly, the pressing demands of military traffic during the Afghan War of 1878-80 made it imperative to improve the line of communication to the Indus crossing at Khushalgarh, and thus the seventy-two mile branch from Golra to Khushalgarh, came into being, and began to carry traffic in 1881. For military reasons also, the Indus Valley threw off a branch from Ruk to Sibi, which was known as the Kandahar Railway. It crosses the inhospitable " putt," and notwithstanding all obstacles and difficulties, so good was the organisation, that for many a year this line held the record for speed in platelaying.

These, then, with the fifteen mile branch between Rajpura and Patiala, were amalgamated on January 1st, 1886, as the North-Western Railway, with a total length of 1,866 miles. The capital outlay booked amounted to £15,000,000 and at the end of that year the gross earnings were £1,690,000 and nett £802,600, exclusive of interest charges.

Thirty years ago the perennial canals existent in the Punjab were the Western Jumna, the Upper Bari Doab and the Sirhind, the semi-perennial Sidhnai, and various minor inundation canals in the Derajat. The first of these was the direct successor of Firozshah's canal of 1350, which after many vicissitudes, had been remodelled and completed in 1878. The Bari Doab (which was started soon after the annexation of the Punjab to find employment for disbanded men of the Sikh armies) had been in use since 1859, whilst the Sirhind had been benefitting the thirsty tracts of the south-eastern Punjab since 1882.

The capital outlay had been approximately £4,300,000 and the area irrigated was $1\frac{2}{3}$ millions acres. The annual value of the crops thus raised was £$2\frac{1}{3}$ millions. The gross revenue of the canals amounted to £291,000 and the nett revenue to £150,000 for the year.

It was acknowledged that these canals, great as they are when considered as individual works, were but a first instalment,

and that the development of the province demanded yet larger and more ambitious schemes. The first of these, the Lower Chenab Canal, which has literally made the desert blossom as the rose, was opened in 1892, and so great was the success which attended the new colony and canal, that the minds of those responsible for the good government of the province looked farther and farther afield, and at the beginning of 1896 the project for the Lower Jhelum Canal was taking shape.

A short though interesting canal opened in 1887 is the Swat, from Abazai on the Swat river near its junction with the Kabul, through Takht Bani and Mardan. Those who pass through this smiling tract to-day find it hard to realise the conditions of life then. The men who built and worked the canal literally carried their lives in their hands, and many a tragedy was enacted before the population of the Yusufzai plain and the border hills had been tamed to follow peaceful pursuits.

During the decade 1886-95, local self-government was being developed and encouraged, with the aid of government grants, to maintain properties hitherto in charge of the Buildings and Roads Branch, though administrative superintendence and advice continued.

Between 1890 and 1896 the frontier was in a disturbed state, and the military operations undertaken were aided by the Buildings and Roads Branch, of whom Colonel LeMeasurier and Messrs. Macdonald, Grant and Fenner specially distinguished themselves.

In 1895 came the siege of Chitral, and a relief expedition soon took the field. The Nowshera-Mardan-Durgai road became their main line of communication, and this was greatly improved and maintained (together with several boat-bridges over the Kabul river) by the Punjab engineers.

In the railway world these ten years were full of incidents and much was accomplished. The Sutlej, already bridged at Phillaur, was spanned some ninety miles lower down by the great Kaiser-i-Hind Bridge at Ferozepore, and the direct approach to Delhi from the north-west was foreshadowed, as soon as trains began to run over it in May 1887.

The troubles and delays on the Salt branch, south of Lala Musa, were obviated by the completion (also in May 1887) of the Victoria Bridge over the Jhelum at Haranpur, and the construction of the Sind Sagar Railway added nearly 350 miles to the system.

The Chenab colony was clamouring for means to transport its newly raised wealth, and as a first instalment, the section of railway from Wazirabad to Lyallpur was built, and working in 1896.

The need for improving railway communication between India and Baluchistan had also been given due weight in the councils of government, and the Sind-Pishin Railway, opened in 1887, had been driven through an inhospitable and covertly hostile country in spite of sickness and difficulties, by the indomitable will of Sir James Brown, whilst Sir Francis O'Callaghan was in great measure responsible for the temporary track up the Bolan, with its section of rack railway at the top of the pass, and for the extension of the standard gauge from Gulistan to Chaman, piercing the Khwaja Amran range through the Khojak tunnel. The Bolan Railway was short-lived, and was replaced by the solidly built Mushkaf-Bolan in 1895.

The interest of native states in railways as profitable investments was steadily increasing, and in this decade we observe the Patiala line extended to Bhatinda, and the Kashmir section of the Sialkot-Jammu line completed.

In Sind the great Lansdowne Bridge over the Indus at Sukkur, with which Fred. Robertson's name is so closely connected, was opened in 1889, and the last link of the through route between Lahore and Karachi was complete, whilst the Hyderabad-Umarkot line stretched out towards Bombay, though by a somewhat indirect route.

The mileage was now 2,654, an increase of some 800 in the decade. The capital outlay of the North-Western Railway and worked lines had reached £32,000,000; the gross earnings £2,045,000, and nett £830,000. Thus, though the capital outlay had more than doubled, owing to the addition of the strategic and frontier lines, the revenue had increased scarcely at all, and the prospects of the line as a commercial proposition were uninviting.

The menace of attack from the far north-west had been prominently before men's minds in the seventies and eighties, and the decade, 1886-95, roughly coincides with the period of greatest activity in matters of defence on the north-west frontier. These defences included works at Karachi, Quetta, Sukkur, Pindi and Attock, with a network of military roads along the frontier, and in certain cases forts and posts commanding the approaches from the turbulent tribal territory. Some

of these works were carried out by the engineers of the province, the majority by the Military Works Department.

Our attention may now be directed to the second decade, *viz.*, 1896-1905. It had been determined that a new frontier province should be formed, mainly from the Punjab, and came into being in 1902. As a result, the Peshawar, Kohat, Hazara, and the Trans-Indus portions of the Bannu and Dera Ismail Khan districts, were transferred, and all their public buildings, roads and canals, passed out of the keeping of the Punjab engineers.

The Coronation Durbar of 1902 gave scope to Colonel Thurburn and his staff of officers to construct works of magnitude and some difficulty in connection therewith, and honours were awarded to Colonel Thurburn and Rai Bahadur Ganga Ram.

In 1905 occurred a cataclysm of nature, *viz.*, the great earthquake of April 4th, which caused widespread ruin, particularly in the Kangra and Kulu valleys, and it became necessary for the Punjab engineers to strain every nerve to make good the damage, and to bring relief to the stricken inhabitants.

The visit of King George (as Prince of Wales) in the winter of that year necessitated much thought and preparation, but though all that was necessary was thoroughly done, the attention of the engineers was by no means diverted from the disaster, which had occurred in the spring, nor were their exertions in any way slackened.

Sanitation in the widest sense of the term had occupied the thoughts of the government and its engineers, but matters moved somewhat slowly at first, chiefly, I fancy, for lack of funds. But the volume of work involved in the construction of water supplies and drainage for the large towns steadily increased from 1885 onwards, and in 1900 a new circle of superintendence (styled Sanitary Engineer) was formed, whose activities are ever increasing, as may be instanced by the drainage system of Simla, with its bacteriological purification of the effluent before final discharge.

The problems involved require the Sanitary Engineer and his staff to possess a knowledge of hydraulics, particularly in regard to wells and the flow of underground water, and he must be aided by the agricultural department in matters connected with sewage farm soils. The returns of disease bear witness to the good work accomplished. With the spread of education we

may hope for better results year by year, as the mass of the people begin to understand and appreciate the benefits of efficient sanitation.

Another branch of the Sanitary Engineer's duties comprises the inspection of steam boilers and prime motors, and in the last ten years the work has increased sufficiently to warrant the employment of two officers for this duty under the Sanitary Engineer.

The Lower Jhelum Canal was opened in 1902 and the colony lands were readily taken up, and a fresh tract of the Punjab put under cultivation, chiefly food grains. The success of the two new colonies only served as an incentive to yet larger and more ambitious schemes, and the irrigation engineers were busied with preliminary work on the great Triple Canal Project, which is designed to bring under cultivation lands lying comparatively close to the hills in the Jhelum and Chenab valleys and south of Lahore in the Bari Doab. The capital outlay on canals to 1905 had been £8,350,000 whilst the gross and nett revenues were £1,423,000 and £910,000 respectively. The area irrigated had risen to $6\frac{1}{3}$ million acres, and the value of the crops to £11,100,000 ; so that in ten years the area cultivated had been quadrupled, the value of the crops had been quintupled, whilst the nett canal revenue had risen from £150,000 to £910,000. This remarkable increase connoted additional railway communications, not only in the newly colonized tracts but also in the valleys of the Sutlej and Indus.

The Southern Punjab Railway Company built a trunk line from Delhi to Samasatta, and not many years after constructed the section from Ludhiana to Ferozepore, and on to Macleodgunge, a station on their trunk line.

In the Indus valley, the objections originally raised by native states holding lands on the left bank of the river had been gradually overcome, and with the completion of the great bridge over the Indus at Kotri, a more direct route to Karachi was available. When the Indus is in heavy flood, this route is less liable to interruption than the older alignment on the right bank and this, during the busy grain season, is no small asset.

During the military operation on the frontier in 1897 and 1898 the strain on the railway had been appreciable, and it was decided that railway communication was required for military reasons to the very border of British territory. Accordingly railways on the 2′-6″ gauge were decided on, and between 1900 and 1904, the Nowshera-Dargai and Khushalgarh-Thal lines

were built on this gauge. As yet there was no bridge at Khushalgarh, and goods wagons with their contents were hauled to and fro across the river on an aerial cable, whilst passengers used the boat bridge.

The length of open line on the system at the end of 1905 was 4,099 miles, built for a capital outlay of £42,260,200. The gross earnings amounted to £4,572,000 and nett to £2,170,000 exclusive of interest charges. The tide then was beginning to turn, for the nett earnings had increased 260 per cent. in these ten years.

We now approach the last of our arbitrary periods, and for convenience may take it to the end of the calendar year 1916, save in the matter of expenditure, which cannot be given in detail beyond March 1916.

With the growth of material prosperity through the province, the problem of utilising electricity for various purposes came more and more to the front, and in 1908 a project for improving the water supply of Simla by electric power, and providing the station with electric light, was put in hand, and has only recently been completed at a cost of £130,000.

Electric light and power are now to be found in Lahore, Lyallpur and Amritsar, and when peace conditions return, many projects for the utilisation of electricity in the chief towns of the province will undoubtedly be taken up by the various municipalities.

In 1912 an Electrical Inspector under the Act was appointed, and this officer, who is responsible for the execution and maintenance of government schemes, also acts as adviser to government and to municipalities under the orders of the Chief Engineer of the Buildings and Roads Branch.

1906 was a year of scarcity, and government, therefore, employed its engineers on extensive famine relief operations.

Owing to the necessity for providing new railway bridges over the Sutlej, Beas and Ravi rivers to carry the greatly increased rolling loads, those originally built were abandoned by the railway. The two first named have been handed over to the Punjab Government, and start a fresh career of usefulness, in that they carry the Grand Trunk Road across these rivers. The Local Government has built a separate bridge over the Ravi at Lahore, the girders for which were obtained from the surplus stock of the railway. The Government of the United Provinces has taken over the old Jumna railway bridge, and thus,

with the exception of the Chenab at Wazirabad, there is uninterrupted communication by road between Saharanpur and Peshawar.

Time does not admit of a detailed reference to the various imperial and provincial civil works carried out, but I may refer to the Namal Dam and the Sialkote Water Supply regarding which papers are to be read and discussed at the Congress.

In Lahore alone the following are monuments to the Buildings and Roads Branch of the Public Works Department. The Chief Court, the Public Works Secretariat, the Veterinary College, Central Jail, Aitchison and Queen Mary's Colleges, the University Hall, the Jubilee Museum and the King Edward Memorial College and Hospital, and this does not exhaust the list for the capital alone.

The need for securing a Consulting Architect to Government had long been felt, and in January 1914, an officer was appointed to whom are entrusted civic and town planning schemes, as well as designs for public, educational, commercial and domestic buildings.

The results of his labours are already in evidence, in the Veterinary College and subsidiary buildings, in the Charing Cross Scheme (not yet completed) and in the Ewing Hostel opened a few months ago by His Honour. All these are at Lahore, whilst at Lyallpur the Lyall Fountain was designed by Mr. Sullivan and opened by Sir Michael O'Dwyer in December last to commemorate the advent of water in that district. It is sad to think that the donor, Sir James Lyall, died but a few days before the opening ceremony was performed.

The Coronation Durbar at Delhi threw heavy work on the Buildings and Roads Branch throughout 1911, for the scheme was truly regal in scope and dimensions, and the honours awarded to Colonel Maclagan, and Mr. Aikman were hardly earned and thoroughly deserved.

The Triple Canal Project to which I have already referred, was begun in 1906, and in December 1915 His Excellency Lord Hardinge opened the last of the great canals, the Upper Jhelum. The project is nearing completion, and it would require a far abler tongue than mine to do justice to the unremitting exertions of the men, who achieved this great engineering feat in spite of unforeseen difficulties. Nor can I adequately picture the material prosperity, which will result. The government, whilst retaining certain lands wherewith to

reward the services of loyal, brave and faithful men, is selling large blocks by auction, and has no reason to complain of the prices realised.

This is in no small measure due to the genius for administration displayed by the colonization officers, who have tended the early years of the Chenab and Jhelum colonies, and have created trust and confidence to which are added the hard headed common sense and practical knowledge of the Punjab agriculturist and horse breeder.

The canal engineer is never satisfied, and even now there are parties in the field working out the details of yet another project, to bring the waters of the Indus from somewhere near Kalabagh to the thirsty lands on the left bank of the river and thus to convert the sparsely cultivated district into a populous and thriving tract of country, and to draw yet further on the waters of the Sutlej below Phillaur.

In these eventful thirty-one years, whilst the area irrigated by canals has risen from $1\frac{2}{3}$ to $8\frac{4}{5}$ million acres, the total area cultivated by canals, wells and tanks has increased from $23\frac{1}{2}$ to $34\frac{4}{5}$ million acres. The value of crops raised by irrigation in 1916 was £18,340,000 as compared with £2,318,000 thirty-one years ago, and this result was obtained by a capital outlay of £$15\frac{1}{2}$ millions, giving a nett canal revenue of close on £1,750,000.

The government and its irrigation engineers may well be satisfied when they contemplate this evidence of schemes well thought out and executed, and the signs of abounding prosperity in tracts, which, but a few years ago, barely supported a sparse nomad population with flocks of goats and sheep and herds of camels.

As I have already said, the North-Western Railway, viewed as a dividend-paying concern, was not, on the whole, remarkable, nor could it be compared in this respect with the irrigation schemes of the province. This was not due to inefficient administration, but in great measure to the fact that in parts it was a pioneer railway, in parts purely strategic. The growing wealth of the provinces it serves, the rapidly increasing population and consequent exchange of commodities make it a difficult matter for the railway to keep pace with public needs. Like a gawky school girl, she outgrows her equipment, first in one direction, then in another, and consequently requires a new outfit.

From time to time her yards are found to be too cramped, her rails too light, her sections between stations too long, the pace at which trains can be handled safely and speedily is not satisfactory, her bridges are found too weak, her workshops and storeyards inadequate, her engines and rolling stock, both passenger and goods, require to be modernized, her staff requires to be housed decently and comfortably. These are but examples of the everyday problems awaiting solution, and, be it remembered, the line, in the broadest sense, must be maintained to standard, and from time to time the attacks of floods must be parried, or the resulting damage made good in the shortest possible time to reduce public inconvenience and loss to a minimum.

But, notwithstanding the unavoidable expenditure thereby entailed, the irrigated tracts were clamouring for improved railway facilities, and so we find that out of 464 miles added to the North-Western Railway proper between 1906 and 1916, nearly 200 were built in the Rechna Doab, whilst the Lodhran Chord of 56 miles was designed and built to shorten yet more the lead to Karachi.

The Kalka-Simla Railway, a remarkable mountain railway on the 2'-6" gauge, brought the summer capital into direct communication with the rest of India, but the expense of construction by a company had been great, and the government took over the line at a valuation soon after its completion, and it now forms part of our system.

The "branch line" terms offered by government (with a guaranteed rate of interest) were inducing private companies seriously to consider railways as an investment, and as a result the rich tract south of Amritsar, the right bank of the Sutlej between Kasur and Lodhran, and the fertile areas north and south of Jullundur, have been traversed by branches financed by companies. To the north of Lahore are the recently constructed Sialkot-Narowal and Mandra Bhaun branches (both built with companies' money), and both promising, even at this early stage.

I have referred to the durbar of 1911. The railway was also deeply concerned, and the North-Western found the majority of the officers and staff who built and worked the Delhi Durbar Railway on both gauges, and their efforts earned the warm praise of those who understood the magnitude of the task of moving the vast crowds which collected on the occasion.

The Kalabagh-Bannu, which is a 2′-6″ gauge strategic line, was completed and opened in 1913, and had it not been for unprecedented rain last year, a subsidiary branch of this line to Pezu and Tank would have been in working order ere now.

On 1st April 1916, the mileage of the North-Western Railway open to traffic was 5,435, of which 643 miles are double track, an increase of 1,336 miles in ten years, and notwithstanding the war, an appreciable mileage of strategic railway will shortly be added to this administration.

The total capital outlay for imperial, native states and companies lines to the end of last financial year, was £63,654,000, the gross revenue £6,444,000 and the nett revenue £2,810,000, exclusive of interest charges.

Native states and companies had spent £6,240,000 and received £405,000, a return of practically 6·5 per cent., while the Imperial Government received 4·3 per cent. on their capital investment, or about one per cent. when interest charges are allowed for.

While these figures pale before those of the Irrigation Department, *viz.*, 7·57 per cent. including, and 10·9 per cent. excluding interest charges, I do not think that the State Administration need hang its head, seeing how large a proportion of the state system cannot, within a conceivable time, make a return on the capital spent. In regard to the native states and companies lines worked by the North-Western there may be considerable confidence in the future, for be it remembered that 500 miles have been in existence less than ten years, and yet another 250 have been opened since December 1914, whilst trade conditions in 1916 were by no means normal.

There is talk of change, and the Public Works Reorganization Committee will visit Lahore in a few weeks' time, to see how the existing system can be altered to encourage industrial activity in the building and allied trades, by calling into being a class of engineering firms capable of carrying through, and to some extent, designing large works for government and for municipalities.

I am not out to express decided opinions, but I am free to confess that if I were on the Commission I should think long and carefully over the matter before I could vote for such drastic changes in this young province.

Gentlemen, I feel I have in no sense done justice to the efforts of the men who are responsible for making the engineering history of the Punjab and the railway since the beginning of 1886, but this is not because I am unsympathetic. I am strictly limited by the hands of the clock, and may, I fear, have overstepped already the limits of your patience. The moral we may learn from a contemplation of the results is that the engineers of the past have ever lived up to the motto of the Corps of Royal Engineers "Ubique quo fas et gloria ducunt." I feel sure that the present coming generation will also keep this motto before them, and this Congress will further stimulate and unite them.

The engineer, be he ever so energetic and enthusiastic, is bound to feel jaded and heart-weary at times, and to all such I would command the lines of Clough, the poet, when he says :—

"Go with the spiritual life, the higher volition and action,
With the great girdle of God, go and encompass the earth,
Not for the gain of the gold, for the getting, the hoarding, the having,
But for the joy of the deed—but for the Duty to do."

APPENDIX A.

General comparative statement illustrating the expansion of the North Western Railway during the past thirty years.

Item.	1886.	1916.	Remarks.
Open line mileage	1,866	5,434	
Number of districts	5	12	
Number of employés	12,250	20,000	
Number of officers	13	37	
Number of engines	591	1,443	
Weight of engines (both passenger and goods).	Increased by seventy-five per cent.		
Mail train loads	Increased by fifty per cent.		
Mail train speeds	Doubled.		
Goods trains loads	Increased by a hundred and fifty per cent.		
Mileage run per engine	Increased by thirty per cent.		
Loco. revenue expenditure ..	48 lacs.	200 lacs.	
Fuel burnt	190,000 tons.*	800,000 tons.	*$\frac{3}{4}$ was wood fuel (Two tons of wood equal one ton of coal).
Cost of fuel per mile run ...	Increased by sixty-three per cent.		

APPENDIX B.

Detailed comparative statement showing the increase in the carrying capacity of the North Western Railway during the past thirty years.

Years.	Number of passengers carried on entire system.	Tonnage of goods carried on entire system.	Number of locomotives at the end of the year.	Number of coaching vehicles at the end of the year.	Number of goods vehicles at the end of the year.	Carrying capacity in tons.	Weight of wheat booked to Karachi.	Remarks.
							Tons.	
Calendar year 1886 ...	9,718,567	2,227,481	587	1,635	8,678	913,554,861	197,302*	*Figures of "edible grains" for first half of 1886 are included. Figures for wheat outlay are not available in the accounts file of that half year.
Calendar year 1896 ...	15,115,217	4,300,697	606	2,121	10,312	1,360,725,024	114,073	
Calendar year 1906 ...	33,587,742	8,044,010	820 34	2,552 80	12,852 431	3,672,727,569 8,766,113	768,665	The lower figures in columns 4 – 7 for the years 1906 and 1915-16 are for the narrow gauge sections included in the North Western Railway system.
Financial year 1915-16...	66,899,142	11,245,601	1,379 64	3,662 306	26,799 568	6,527,305,762 29,656,318	630,387	

APPENDIX C.

Statement showing Mileage, Capital Outlay, Earnings and Working Expenses of the North Western Railways System at the end of each decade from 1886.

Year.	State Lines.	Native State Lines.	Companies Lines.	Remarks.
1886.				(*a*) Rajpura-Patiala.
Mileage	1,851	(*a*) 15	*Nil*	(*b*) Sind-Sagar Ry. ... 349 Sind-Peshin Ry. ... 206 Wazirabad-Lyallpur .. 38 Jammu-Kashmir Ry.... 8 Ganda Singh-Husainwala 10 Minor additions .. 9 Previous 1,851 2,471
Capital Outlay Rs.	22,25,06,000	12,29,000		
Earnings ,,	2,53,05,000	64,000		
Working Expenses ,,	1,32,83,000	45,000		(*c*) Patiala-Bhatinda ... 93 Jammu-Kashmir ... 16 Hyderabad-Umarkot ... 59 Previous 15 183
1896.				(*d*) Kotri-Rohri Ry. ... 179 Wazirabad-Lyallpur ... 115 Lyallpur-Khanewal ... 49 Ferozepore-Bhatinda... 54 Jech-Doab ... ... 46 Hyderabad-Badin ... 62 Minor additions ... 13 Sind-Sagar ... ... 119 Peshin Section ... 185 Nowshera-Dargai ... 40 Kohat-Thal ... ... 62 Previous 2,471 3,395
Mileage	(*b*) 2,471	(*c*) 183	*Nil*	
Capital Outlay Rs.	47,11,39,000	94,57,000		
Earnings ,,	2,94,42,000	12,40,000		
Working Expenses ,,	1,75,24,000	7,03,000		(*e*) Patiala-Bhatinda ... 107 Jammu-Kashmir ... 16 Ludhiana-Dhuri-Jakhal 79 202
1906.				
Mileage	(*d*) 3,395	(*e*) 202	(*f*) 502	(*f*) Southern Punjab ... 425 Ludhiana Extension ... 77 502
Capital Outlay Rs.	58,96,96,000	1,19,52,000	3,22,55,000	

APPENDIX C.—*concld.*

Year.	State Lines.	Native State Lines.	Companies Lines.	Remarks.
				(*g*) Main Line 464
				Sind-Sagar 4
Earnings ... Rs.	6,18,66,000	19,09,000	48,11,000	Kalka-Simla 59
				Kalabagh-Bannu ... 89
				616
Working Expenses ,,	3,24,91,000	10,14,000	25,01,000	Peshin Railway dismantled ... ... −2
				614
				Previous 3,395
				4,009
1916.				
				(*h*) Khanpur-Chachran 22
Mileage	(*g*) 4,009	(*h*) 224	(*k*) 1,201	Previous 202
				224
Capital Outlay Rs.	86,12,21,000	1,40,12,000	7,95,93,000	(*k*) Amritsar-Patti-Kasur 54
				Ludhiana Extension ... 75
				Jullundur Doab ... 130
				Sutlej Valley 208
Earnings ... ,,	8,41,07,000	27,72,000	98,02,000	Jacobabad-Kashmore... 77
				H. D. B. Railway ... 71
				Mandra-Bhaun ... 46
				Sialkot-Narowal ... 38
				699
Working Expenses ,,	4,80,43,000	14,35,000	50,35,000	Previous 502
				1,201

Totals for 1916—

Mileage	5,434 miles.		
Capital Outlay	... Rs. 95,48,26,000	=	£ 63,655,000
Earnings	... Rs. 9,66,61,000	=	£ 6,444,000
Working Expenses ...	... Rs. 5,45,13,000	=	£ 3,634,000

APPENDIX D.

Statement showing mileage of channels, gross area commanded, culturable area commanded, and areas cultivated and irrigated by all kinds of irrigation works in the Punjab at close of each of the decennial periods commencing from 1864-65.

Year.	Mileage of channels.		Gross area commanded by canals.	Culturable area commanded by canals.	Area irrigated by canals.	Total cultivated area in the province including irrigation by wells and tanks, etc.	Percentage of canal irrigation.	Total value of crops raised by canal irrigation.	Remarks.
	Main Canals and Branches.	Distributaries.							
1	2	3	4	5	6	7	8	9	10
	Miles.	Miles.	Acres.	Acres.	Acres.	Acres.	Acres.	£	U. B. D. Canal under construction, 1851-61. Sirhind Canal under construction, 1870-84.
1864-65	...	...	...	...	764,268	20,168,000	3·79	1,993,900	Sidhnai Canal under construction, 1886-89.
1874-75	...	Not available.		...	1,208,073	19,909,000	6·05	2,114,500	Sirhind Canal opened, 1882.
1884-85	..	...	...	...	1,614,288	23,518,686	6·86	2,318,000	L. C. Canal under construction, 1885-92.
1894-95	4,366	8,987	12,912,627	9,997,692	2,726,821	26,461,101	10·30	4,793,100	L. C. Canal Extension Project corporated, 1900.
1904-05	4,724	12,775	18,361,186	15,802,041	6,306,384	27,596,026	22·85	11,097,400	L. J. Canal under construction, 1899-02.
1915-16	4,332	14,474	21,526,607	18,232,314	8,884,811	34,865,000	25·45	18,340,000	Triple Canal Project under construction, 1906-16.

APPENDIX E.

Statement showing the financial results of irrigation works of all kinds in the Punjab at the close of each of the decennial periods commencing from 1864-65.

Year.	Capital outlay direct and indirect to end of year.	Gross revenue during the year.	Working expenses during the year.	Net revenue during the year.	Remarks.
1	2	3	4	5	6
	Rs.	Rs.	Rs.	£	
1861-65	1,49,51,549	18,18,045	6,49,145	77,920	
1874-75	2,97,04,746	25,44,610	11,81,714	90,860	
1884-85	6,42,57,811	43,75,915	21,37,672	149,200	
1894-95	8,99,14,208	72,81,599	36,46,242	242,360	
1904-05	1,249,59,865 (£ 8,350,000)	2,13,44,117 (£ 1,423,000)	77,18,768 (£ 514,584)	180,356	
1915-16	23,32,91,452 (£ 15,553,000)	3,89,64,665 (£ 2,600,000)	1,28,20,261 (£ 854,684)	1,743,000	

SPEECH

BY

SIR MICHAEL O'DWYER, K. C. S. I.,

LIEUTENANT-GOVERNOR OF THE PUNJAB.

COLONEL CRA'STER AND GENTLEMEN, I very highly appreciate the honour of being asked to attend this annual Congress for the second time. I had not intended to say anything on this occasion, but the eloquent and comprehensive address we have heard from Colonel Cra'ster, reviewing the engineering progress of the last thirty years, has encouraged me to make a few remarks.

In the first place the meeting of the Congress here this year is a very remarkable fact. We all know to what extent the various engineering services have been depleted owing to the war. They have given of their best in the service of their country. They may well be proud of what they have done, but the sacrifices they have made have entailed great additions to the arduous duties of the officers left behind. I can bear testimony to the services which the Services controlled by the Provincial Government have given, and to the cheerful and ready way in which they have responded to the call.

The absence of officers on active service has often meant double duty and refusal of leave for those left behind, and yet I have heard not one single word of complaint. I doubt even if the work of the various departments has ever been carried out as efficiently as it has during the past two years. The North-Western Railway has sent to the front many of its best officers and has had to cope with most unusual conditions of traffic. These conditions have been extremely difficult, and the North-Western Railway has risen splendidly to the occasion. From the financial point of view, previous records have been exceeded by a hundred lacs. The Irrigation Department has also had to face unusual difficulties, two cold weathers having gone by with practically no rainfall. Last year the department coped with those difficulties with remarkable success, and distributed its scanty supplies with justice and discrimination, thereby preventing distress and enabling the Punjab to send large supplies of wheat to the home country and our allies.

It is now dealing with similar conditions, and I am confident that its efforts will be crowned with success. Last year's return of the Irrigation Department have exceeded all records. The Buildings and Roads Branch are equally willing and equally ready to do their part, but unfortunately financial stringency has compelled us to cut down expenses. You will be glad, however, to learn that this financial stringency has been relaxed, and that during the coming year the Buildings and Roads Branch will have a wider field of operations.

I mention these facts to show how splendidly the various engineering departments have risen to the strain and stress of the last two years.

But, Gentlemen, your presence at this Congress is a remarkable proof of the vitality and the strength of the movement which finds expression in your proceedings. It is proof that you have not only been able to cope with the daily problems, but that several of your members have been able to find time for scientific investigations and research, and have been able to produce papers, which, after discussion here, will, I am sure, help the engineers to assist the Government in the solution of the many great problems confronting us.

Listening to the comprehensive and interesting address, in which the President has described the progress during thirty-one years, I may say I personally was specially interested, as my own connection with the province goes back thirty-one years, and synchronizes, therefore, with the organization of the North-Western Railway, and the official career of your President. It is interesting to be taken back to those days and to be allowed to survey the past achievements of engineers.

I might say that Colonel Cra'ster is peculiarly fitted to review what has happened during that period, not only by his position as a distinguished engineer, but also because of the fact that he is now the head of one of the greatest railway organisations perhaps in the East. The North-Western Railway not only creates, but also reflects progress, and, therefore, the head of it is in a position to show how roads and canals serve the purposes of the railway and the railway serves the purposes of the roads and canals. In conjunction with one another, they all play their parts in the progress of the country as a whole.

We know what great problems are before us, especially in the matter of hydraulic developments ; we know of the great success which has attended the expansion of railways in the Punjab, and all this gives promise of further enormous develop-

ments when normal conditions are restored ; nearly every district in this province is clamouring for further railway extensions. We have under consideration in the Irrigation Department some of the biggest schemes the world has ever seen ; therefore, those of you who have a stretch of service before them, can look forward to being associated with even greater works than the works of the past, and of carrying them out with that spirit of energy, devotion and unselfishness which has ever characterised the engineers of the Punjab.

The papers which are to be read and discussed at this Congress indicate the close touch which the engineers in the various departments are maintaining with the vital problems of practical development. Looking at the agenda we have the water supply at Sialkot—a work in connection with which Mr. Aikman has achieved considerable success. He showed that the water supply of Sialkot could be met by a few tube wells ; his forecast was rather a daring one, but it has been amply fulfilled. The success of this scheme will enable other towns of the Punjab to embark confidently on similarly schemes for water supply. Then we have on the agenda a paper on surface drainage by Rai Sahib Amar Nath, who has already made a name for himself as a sanitary engineer. Every big town has still a project for improving its sanitary conditions, and I am sure the paper and the discussion thereon, which is coming, will help considerably towards elucidating those problems.

As regards the papers coming up for discussion at the afternoon session our friend, Mr. Maynard, who is attending the Congress, will be able to throw light on the questions to be discussed from the revenue point of view, which will help us to realize the enormous part this question will play in the development of the Punjab. The most acute problem, as I mentioned last year, and as the experience of the last two years has brought home to us all, is now the maximum value to be obtained from the cusec, and the papers on the agenda are directed towards solving this problem. I have rarely seen a collection of engineering papers, which appeal so directly to the ordinary man in the street, like myself ; for I realise that a discussion on these subjects will help enormously, not only towards the successful work of the departments concerned, but also the peaceful prosperity and health of the community at large.

I thank you, again, Gentlemen, for your kindly welcome to me and wish you an interesting and profitable discussion on the various subjects before you.