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By

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This paper deals with the Uhl River Hydro-Electic Project planned to provide cheap and better electric power for domestic as well as industrial users of Punjab. The site of this project is located in Mandi State, about 200 miles North-East of Lahore. The difference of levels between Uhl and the adjoining Rana Valleys is about 2000 feet. In order to utilize this difference to generate hydel power, diversion of Uhl water by tunnelling through the ridge separating the two valleys is the only practical alternative available. The problems encountered in planning, design and construction of this tunnel are discussed. This power project shall be in three stages to produce a total of 120 MW. Work on the first stage is in progress, and this requires storage of 7 million c.ft in the Uhl. For the 2nd stage, a 250' high dam is proposed. The 3rd stage shall be within Rana Valley by using a 1200' drop and building another power house.

The main geological feature of the ridge is a wide cyncline. Composition of the ridge through which tunnel is driven consists of granite gneiss, mica schists, felspathic quartz gneisses, white and gneiss quartzites etc.

A base line 900 feet long was chosen for the start of work for layout of tunnel and triangulation right over the hill was carried out. The proposed tunnel centre line was connected to this line near the north portal and at surge shaft and tunnel exit. Vertical angles were read as a check on double precise leveling which connected up the power station and the headworks area.

A number of factors governed the exact location of tunnel. The tunnel intake would be downstream of the junction of the Uhl and Lambha Dag streams. The locations of the diurnal reservoir and dam site finally fixed the location of tunnel intake on northern side. Surge shaft and pipe line location finally decided the position on the Southern side. Suitability for establishment of haulage facilities over the high ridge, level 8540, also played a role in selection of the tunnel site. Surveys indicated that a side entrance (adit) could be obtained through a nullah for expediting the work of tunnelling. However in order to decrease the length of adit by nearly 700 feet a bend was introduced in the main tunnel and its length increased by 80'. Its total length is about 14000'.

Originally, the tunnel had been designed of circular shape to withstand heavy internal hydrostatic pressure. the friction loss was calculated to be 2.22 ft. per 1000 feet with a friction co-efficient N of 0.014 for a discharge of 600 Cs at 9 ft. per second velocity in a tunnel of 9-3" diameter. Circular section proved to be a failure in the areas of poor quality or granite gneiss and a plain arch section was adopted in such areas. The gradient of 0.8997%, originally projected for the northern heading, was changed to 3.5% owing to the likelihood of large gushers of water being met in the granite gneiss. The gradient was fixed in such a way that the natural drainage system would work through the southern adit.

Special equipment and total power of 1080 K.W. had to be provided for construction. The compressors were located alongwith the sub-station plant at portal: two of these at north portal and three at south portal. Later on, one more was added at the southern side. Each compressor station was also equipped with a pair of blowers which were necessary for ventilation. Centrifugal pumps of 2" and 4" size were used for the water requirements of concrete work. The mucking machine worked with water taken from different pumping stations located along the tunnel site.

Size of the cross-section to be excavated, the nature of rock and type of equipment available are important factors which determine the method of tunnelling. In this case as the tunnel cross-section was small and rapidly working mucking machines were available, the entire section has been drilled and blasted in one operation. For loose rock, a top heading method was adopted. Where mucking or haulage were interrupted by other work in the tunnel, a bottom heading had been used. Cement grouting proved successful for the areas of loose boulders.

The quality of rock being excavated fixed the depth and spacing of holes to be drilled for blasting. Jack hammers, weighing 55 Lbs, were used for almost the whole of the tunnel. Three face blasts per day were possible in 8 hours shift but this target usually could not be achieved due to other works. Pilot holes from 12 to 16 feet were drilled to locate the water areas in granite fissures. Gelatine dynamite (60%) commonly known as gelignite suitable for work in wet conditions was the principal explosive used with electric detonators in all headings. The state of rock in the south heading was not of good quality and therefore more overbreakage occurred as compared to the north heading. Due to this fact, 100 percent excess quantity of concrete was needed for srengthening of roof. Usually no heavy blasting was permitted within 800 of lining in order to prevent damages to concrete.

As timber initially used for supporting the roof proved to be decaying quickly in underground conditions, it was replaced later on by steel frames and precast RCC slabs in all headings. This arrangement showed satisfactory results and its use was all the more necessary because timber should not be concreted in along with the lining.

Two Myers-Whaley Type-4 mucking machines for the Northern heading and one of the same type for the Southern heading were employed. These machines proved satisfactory in dry conditions but when considerable quantity of water was encountered, serious delays occurred. In the Southern heading, conditions for the use of these mucking machines were more favourable because of no accumulation of water and rapid haulage of muck out of the tunnel due to down ward natural gradient. Ten ton electric locomotives on narrow (2'-6") guage rail track were used for haulage. It was found that there was very little difference in the cost per foot of tunnel excavated whether hand or machine mucking was employed.

Different methods and rates were employed on different headings. On the Southern side rock was in shattered shape, therefore more difficulties were encountered as compared to those on Northern side. On the Northern side, all work was carried out by daily labour with some incentives of bonus. At the Southern heading ordinary muster roll system of payment plus some bonus was tried but because of the hard nature of work, monthly work orders system offered to contractors proved more workable. The rate of labour and explosives paid to contractor was Rs. 60 per foot run with a progress of 150' per month. An average progress of 5.4' per day has been maintained in the Northern heading with 3.6' for midpoint heading and 4.2' for surge shaft heading. The total cost of driving per foot run inclusive of timbering or steel setting and RCC slabs amounted to Rs. 145 for Northern and Rs. 178 for Southern heading.

In the design of a tunnel the forces which must be considered are; the pressure of the materials through which the tunnel is drived, the external water pressure, the internal water pressure and the stresses due to changes in temperature. Rocks deform under the influence of pressure in two ways, one of a permanent nature and may be termed as the plastic limit, and the other of a temporary nature and may be defined as the elastic limit. Plastic deformations which are very dangerous in pressure tunnels may be minimized by preventing movements during driving which may otherwise develop very high pressures. it is, therefore, advisable to be careful in the removal operation of timbering and the quickest possible placing of lining. The risk of leakage is always minimum in those areas where external water pressure is considerable, therefore pressure tunnels should be located as deep as possible below ground level. Experiments have shown that generally influence of variation in temperature does not reach more than about 10 feet beyond the lining.

The lining of the pressure tunnels should be capable of withstanding any external pressure which may be exerted by the surrounding rock. Therefore if all cavities are carefully filled, a circular concrete lining of one foot thickness can take any pressures likely to rise. Grouting of cement sand slurry was extensively applied to fill the cavities. Effect of internal hydrostatic pressure can be minimized either by reinforcement of concrete lining or by high pressure grouting of the surrounding rock. In this tunnel after the main concrete lining, an inner layer of reinforcement was added which was covered by means of gunniting with cement sand slurry 1:2.5 with a cement gun. This system needed no centering and a high rate of progress was achieved.

The total cost per foot run of lining, excluding the mantle, of the surge shaft heading was Rs. 157 and of the mid-point heading Rs. 162., The cost per foot run of mantle in the Southern heading amounted to Rs. 160.

At the time of writing the paper, a tunnel length of about 1300 feet was still to be driven for the connection of two headings. The actual behaviour of the tunnel could only be seen after putting it in operation. The power supply operations were planned by 1933.

Note :

Paper No. 155 appeared at pages 35 to 76 of the proceedings of Punjab Engineering Congress 1932 Vol. XX. It has some photographs and 12 plates. For details of construction the interested reader may see the original paper.

The discussions and later developments are given at pages 76a to 76p. The two main headings met on 29.2.32 the discrepancy in level being 1/10 inch and in alignment 11/16 inch. The tunnel was tested in September and found to be water tight. In fact due to high external pressure there was an inflow of about i cusec.