STATE OF NEVADA - DEPARTMENT OF HIGHWAYS
MATERIALS AND RESEARCH LABORATORY

January 17, 1963

Control Section: EL-81
E. A. No.: 70012-2

Mr. O. W. Walker
Chief Road Design Engineer
Department of Highways
Carson City, Nevada

Dear Sir:

SUBMITTED FOR YOUR CONSIDERATION IS:

REPORT

OF

GEOLOGICAL INVESTIGATION

OF TWO ROCK CUTS

& ONE TUNNEL SITE

IN CARLIN CANYON, ELKO

COUNTY, NEVADA

Very truly yours,

Tom Cordova

Tom Cordova
Engineering Geologist

TC:db
Distribution:
1 - Construction Engineer
1 - Bureau of Public Roads
1 - Chief Road Design Eng.
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## GENERAL GEOLOGY

The Carlin Canyon area is located at the intersection of the westward-flowing Humboldt River and an unnamed range of hills. These hills trend north-south and are probably a northern extension of the Pinyon Range.

In the vicinity of the examined area, Mississippian chert-pebble conglomerates (Tonka fm.) are separated by an angular unconformity from the overlying (Strathearn fm.) calcarenites of Late Pennsylvanian age.

### TONKA FORMATION

The Tonka formation consists of brown-weathering, chert-pebble conglomerate with quartzite and fossiliferous calcareous interbeds.

The coarse conglomerates and quartzites crop out as a series of bold, dark brown or reddish brown cliffs and ledges with intervening poorly exposed, impure, fossiliferous limestones and siltstones. The conglomerates consist predominantly of subangular to subrounded dense chert-pebbles and some granules. There are varying hues of gray, green, brown, black and red. Close examination generally reveals a few subrounded to round quartzite pebbles and cobbles of varying hues of grey and black. As no argillaceous, carbonate, igneous, or other rock fragments were observed, these are typical oligomictic conglomerates because they are composed of only two resistant rock types. Measurements indicate an average size of the conglomerate pebbles to be 3/4 to 1 1/4 inches in diameter. Sorting is poor to moderate. Less than 10 percent is of sandy matrix of subangular quartz and chert.

Sandstone and siltstone comprise less than one third of the formation and consists of subangular to subrounded, poorly sorted quartz and chert grains, commonly with scattered chert granules or pebbles. Cement consists of hematite or limonite, quartz and minor chalcedony. These rocks are classed as ferruginous quartz-chert arenites and siltstones. They, as well as the conglomerates, are so firmly cemented that most sand grains and pebbles break through rather than around their boundries.

The Tonka formation is thought to have been deposited seaward from a rugged, rising, sea-cliff coast. Accumulation must have been rapid, but probably with many brief interruptions.

Stratification or bedding is generally 3 to 5 feet thick and indistinct within a unit, but may be sharp between differing lithologic types, especially where weathering has produced a parting or separation plane.

Calcareous interbeds are light gray, pinkish, grayish yellow, or light brown, quartz-silty limestones and calcareous siltstones with wavy laminated bedding. Dark clay shale, and olive-drab quartzites and siltstones are interbedded in the formation.

## STRATHEARN FORMATION

Quartz-silty limestone and thin, commonly cross-bedded, chert granule and pebble conglomerate make up the Strathearn formation. The limestones are quartz-silty or sandy and may have scattered, fine, chert fragments. Nodular chert is very rare, but does occur in a few purer limestones. Few units exceed twenty feet in thickness. Stratification is indistinctly thin - to thick - bedded in purer limestones, but more distinct and thinner in sandy or conglomerate units. Parting is generally flaggy to blocky.

Grayish yellow-weathering, calcareous, quartz siltstones are common in the formation and characteristically contain fossils.

The Strathearn formation, is generally characterized by chert-granular beds and and abundance of very silty units.

# CUT SITE STUDIES

## "A" LINE

**STATIONS 1751 to 1762**

The cut at this site would be 260 feet deep. The cut is located in the Tonka formation which strikes from N 13 W to N 21 E at this location and dips from 80° to 89° to the east. The direction of the "A" line is approximately normal to the strike of the Tonka formation at the cut site.

The coarse conglomerates and quartzites that make up the cliffs and ledges in the area are very stable and erosion resistant, but the intervening, impure, fossiliferous limestone and siltstones are very erodible. Since the formation dips so steeply and strikes normal to the "A" line it is the opinion of the writer that raveling and sloughing of the siltstones would be excessive at a cut slope design less than 1:1. Therefore a 1:1 backslope with 50 foot intervals between benches is recommended.

Provisions should be made for access to the benches to facilitate cleaning, as a large amount of raveling from the siltstones and calcarenites would be expected.

<u>"B" LINE</u> — <u>STATIONS 1780 to 1793</u>

The cut at this site would be 220 feet deep. The cut is located almost entirely in the Strathearn formation of quartz-silty limestone. Approximately 100 feet is located within the Tonka formation. The cut section is located on a curve and the strike of the formations vary from near normal, to parallel to the direction of the "B" line.

The strike of the formations is in part parallel to the axis of the "B" line and in part normal to the axis. The strata predominantly dips toward the north, and there is danger of sliding on the south slope; hence, a nonsymmetrical cut with one slope flatter than the other should be designed.

The dip of the strata is mostly 45° to the NE in the cut area and it is the writers' opinion that a 1/2:1 slope with 50 foot benches is feasible for the north cut slope.

The south cut slope will have to be designed at 1 1/2:1 to eliminate the possibility of slides. A 1:1 slope would coincide with the dip of the strata and thus bedding plane slides would be frequent, especially during the wet months. A steeper slope is not desirable as this would be conducive to the unstability of the slope since the strata dip toward the axis of the cut. Fifty foot intervals between benches are recommended for the south cut slope.

The material removed from the cut is a possible source of base and surface aggregate for the highway in the Carlin Canyon area. There is adequate room for a crushing plant between the Humboldt River and the west end of the cut section. The aggregate required for the highway in this area is approximately 250,000 cubic yards.

## TUNNEL SITE STUDIES

"C" LINE

STATIONS 1774 to 1793

Geology - A detailed examination of the tunnel site area was made by the writer. This included the examination of the surface geology and underground geology. The underground geology was examined in the Southern Pacific Railroad tunnel and in the Western Pacific Railroad tunnel which run parallel to the proposed highway tunnel. The excellent geologic data obtained from the surface and underground precludes the necessity for bore holes in this area.

The tunnel bores will intersect both the Tonka and the Strathearn formation. The strike of the formations is very constant for both the surface and underground geology and averages N. 20 W.. The dip varies, and apparently increases in angle at greater depth within the mountain. The surface geology indicates a 48° to 86° SE dip while the dip at the railroad tunnel elevations of 4960 feet is quite consistent at 80°-85° SE. It is the opinion of the writer that 60°-85° SE dips can be expected in the highway bores.

Two major sets of joints were recorded. The first strikes and dips regularly at N. 70° E., 80° SE. The second strikes regularly at N. 75 W. but the dip varies from 10° SW to 80° SW. Spacing of the joints is usually from 2 to 5 feet. The N. 70 E. joint is of prime importance since this joint is transverse to the bedding planes and most of the breakage during excavation will be along this joint with blocks tending to slide into the tunnel along downslope bedding planes.

Support & Lining - The bedding planes of sedimentary formations naturally affect the stability of the tunnel section bored through them; the angle made by the line of the tunnel with the strike and dip of the beds is a most important feature. The strata in Carlin Canyon strike and dip at an oblique angle to the line of the tunnel. (See figure 2) The angle between the strike of the formations and the axis of the tunnel is 30 degrees.

The overbreak, which is estimated to be less than 10 percent, will tend to produce an irregular peaked roof, (see fig. 1), and blocks will tend to slide into the tunnel along downslope bedding planes. Pressure concentrations will be at one side of the tunnel when oblique strata are bored through. Eccentric loads will be imposed on the supports, which must be properly backpacked and designed to carry such loads.

The rocks in the tunnel area are moderately jointed, but the blocks between joints are so interlocked or secondarily cemented that the vertical tunnel walls will not require support. This is evident from examination of Southern Pacific Railroad tunnel. In this tunnel 4x4 timber backpacking are in a loose condition after 50 years. The 4x4 timber will move slightly when struck with a prospector's pick. Horizontal sheathing are in very good condition and show no evidence of horizontal pressures having acted on them. Where conditions are encountered that do need support it is suggested that rock bolts be used.

A considerable number of theories that assume uniformity in the material surrounding a tunnel are discussed in various literature. In practice, such theories are seldom used, and a quantitative solution to the lining problem does not exist; hence, lining design is based mostly on practice and engineering judgment. A rule that has been used to some extent as a guide only is to allow 1 inch of lining thickness for each foot of tunnel diameter. The vertical pressures may be symmetrical or nonsymmetrical.

Jointed and stratified rock, such as these, generally need lining. Practice shows that the vertical pressure on the roof of a tunnel in rock is generally independent of the depth, and the shape and size of the caving zone are practically the same regardless of depth.

For convenience in design computations, the weight of the actual rock body exerting vertical pressure on the lining is replaced by an equivalent uniformly distributed load, which is expressed in feet of overburden. This is known as rock load.

Lining in stratified or moderately jointed rock has to support only some loose rock from overbreak. The height in feet of the corresponding uniformly distributed rock load may be estimated at no more than 0.25 of the width of the tunnel in feet.

The heaviest rock at the tunnel location is the limestone which has a weight of 165 P.C.F. The weight of the conglomerate is 160 P.C.F. and average of the siltstones and sandstones is 150 P.C.F.

Thus assuming a width of 36 feet for the tunnel the maximum rock load expected would be 0.25x36x160# equals 1440 P.S.F.

If tunnel supports are placed and backpacked immediately after shooting, frictional forces acting along the fractures between the roof and the natural vault above the roof transfers a portion of the weight against the rock located beyond the sides of the vault. The vault is the natural shape of the void above the roof that would form with no roof support. Hence the load over an adequately backpacked roof support is likely to be much less than the estimate of 0.25 the tunnel width.

For estimating purposes it is estimated that 60 percent of the tunnel will need roof support. Because of the changes in the condition of rock encountered as a tunnel is driven, it is found in actual practice that the spacing and location of the supports should be modified to meet the conditions as they exist at any given section of the tunnel. From the geology it appears that the first 300-400 feet of each portal will require the most support. The joint spacing and bedding thicknesses indicate that the maximum spacing between supports should be no greater than five feet.

Since the roof load is not anticipated to be excessive and support for the vertical walls will not be necessary, except by bolting, a feasible type of support might be the steel rib and wall plate type. This type is especially applicable where only a light roof support is needed.

Examination of the area indicates that ground water will not be encountered during tunnel construction.

## CONCLUSION

The conclusion of the writer is that a tunnel at this location is feasible. The material through which the tunnel will be constructed is not "heavy" ground and approximately 60 percent of the tunnel will need roof support. None of the vertical walls will need steel support except by the rock bolt method. Probable types of roof support could be by the steel rib and wall plate method.

Overbreak is estimated to be less than 10 percent with present construction methods and ground water will not be encountered at the site.

Since tunnel engineering and site examinations require a great deal of knowledge and experience the writer would welcome a review of this report by someone more experienced than he is. Possibly a review and field examination by Mr. C. H. Harned of Clair A. Hill and Associates of Redding, California would be beneficial.

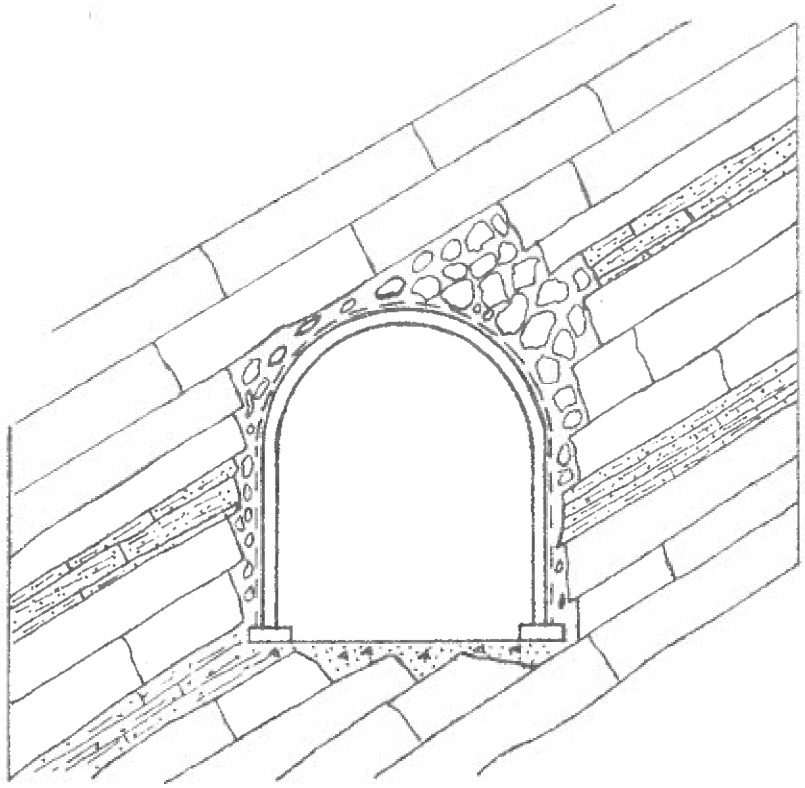

Fig. 1

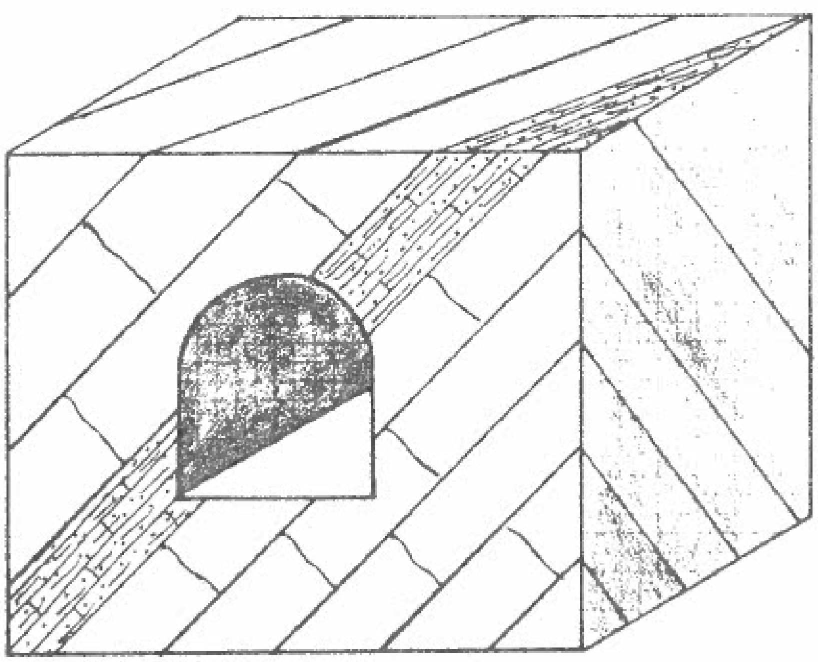

Fig. 2