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# SSC RELATIVE AND COMPARATIVE TUNNEL COSTS

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The dominant feature of the SSC is the Main Collider Ring, which is of the order of 60 miles for magnets which are not iron-dominated. One can consider reducing the length of the Collider Ring tunnel as a means of cutting project costs. For a given magnet choice, this would result in lowering the energy of the accelerator below its nominal energy of 20 TeV. Alternatively, one may preserve the energy of the machine at the reduced tunnel length by using correspondingly higher-field magnets. In the latter case the increased cost and complexity of the higher-field magnets and increased synchrotron radiation must be balanced off against savings in the cost of the tunnel.

To put these choices into perspective, two sets of figures and tables have been drawn up.

## I. Relative Tunnel Costs

Figure 1, with Table I, illustrates the costs of the tunnel and associated components relative to the costs of those conventional construction components of the project which are invariant with respect to tunnel length, e.g. the Campus, Injector, Experimental Areas and the Refrigerator Stations. The data used are drawn from the Reference Designs Study along with some data from a study of a Fermilab sample site which supplement the Reference Designs data.

It appears from the data that cost savings due to relatively small changes in the length of the tunnel are overwhelmed by the overall conventional construction costs for the project and are within the spread in the cost estimates. Those savings in addition could be overwhelmed by a too conservative choice of tunnel cross-section or of installed utilities or invert. It would appear that any relatively small variation in the length of the main Collider Ring tunnel could not be justified on the basis of estimated savings in conventional construction costs.

## II. Comparative Tunnel Costs

Figure 2, with Table II, illustrates the comparative costs of a 12-foot diameter SSC tunnel as estimated for the Reference Designs Study in limestone and by Harza Engineering in a known dolomite, along with the actual bid price in late 1984 for a similar tunnel in the same dolomite. These three examples are for 12-foot diameter tunnels without invert or utilities; i.e., bare tunnels as left by the tunnel boring machine (TBM). For comparison, a curve is added showing a Harza estimate for boring a 9-foot diameter tunnel in dolomite including notches at invert level to improve the base width. Finally, the cost is shown of the mixed-ground tunnel from the Reference Designs Study for the Type A magnet (6.5 tesla) case.

The spread in the estimates and the comparison with experience make it difficult to use ring circumference as a variable in arguing cost savings in the 5-7 tesla range. It is probably more useful to consider the cross-section of the tunnel and the particular medium traversed than the length of the tunnel in searching for economies in the costs of the conventional construction. Cost variations in these are of the same order of magnitude as for variations in length, but these do not impact the beam energy, which is a fundamental technical parameter of the accelerator.

TABLE I

SSC RELATIVE TUNNEL COSTS
(w/o Contingency or EDIA)

I. Collider Ring Invariants

1. Experimental Areas (4)

a. Reference Design

| | |
|---|---|
| Interaction Enclosures (70'x75'+2·40'x45' + access constr 150'x125') | $52.5M |
| Land Improvements | 0.5 |
| Staging Buildings (304'x123' above access) | 18.3 |
| Ancillary Buildings | 0.3 |
| Utility Systems | 16.0 |
| | $87.6M |

b. Harza

| | |
|---|---|
| Interaction Enclosures (50'x50'+2·36'x25' + access 75'x50') | $29.6M |

2. Main Ring

a. Reference Design

| | |
|---|---|
| Land Improvements | $15.0M |
| Cryogenic Facilities, Surface | 8.0 |
| Cryogenic Facilities, Underground | 8.9 |
| Support Buildings | 1.7 |
| Utility Distribution System | 38.0 |
| Beam Abort | 8.0 |
| RF | 0.2 |
| | $79.8M |

b. Harza

| | |
|---|---|
| Shafts | $32.2M |
| Cryogenic/Power Supply Vaults | 37.7 |
| Minor and Isolation Vaults | 9.9 |
| Injection Adits | 13.1 |
| | $92.9M |

3. Totals:

| | |
|---|---|
| Reference Design | $158.5M |
| Harza | $122.5M |

II. Collider Ring Variables

1. Tunnel Boring, Length

a. Reference Design

| | |
|---|---|
| Rock (12'Ø), igneous and limestone | $1130/ℓ.f. |
| Soft Tunneling (11'Ø) | 1012/ℓ.f. |
| Cut-and-Cover (9' ID) | 755/ℓ.f. |
| Average | $ 896/ℓ.f. |

| | |
|---|---|
| b. <u>Harza</u> | |
| Rock (12'Ø), dolomite | $ 879/ℓ.f. |
| c. <u>TARP Experience</u> | |
| Rock (12'Ø), dolomite | $ 775/ℓ.f. |
| .2. Tunnel Boring, Diameter[1] | |
| a. Rock (8'Ø), dolomite | $ 739/ℓ.f. |
| b. Rock (9'Ø), dolomite | 778/ℓ.f. |
| c. Rock (9'Ø with notches), dolomite | 794/ℓ.f. |
| d. Rock (10'Ø), dolomite | 809/ℓ.f. |
| e. Rock (12'Ø), dolomite | 879/ℓ.f. |
| 3. Utilities, Ventilation, and Drainage[2] | |
| a. Utility Support and Distribution | $ 140/ℓ.f. |
| b. Ventilation | 2/ℓ.f. |
| c. Drainage | 3/ℓ.f. |
| 4. Invert | |
| a. Reference Design (surface drain trough), cast | $ 60/ℓ.f. |
| b. Harza (9'Ø) (9 ducts and a surface drain), cast | 230/ℓ.f. |
| c. Harza (9'Ø), precast slab | 242/ℓ.f. |

[1] Harza Studies.

[2] Reference Design backup.

Figure 2 - Comparative Costs of Tunnel Boring: Limestone/ Dolomite (w/o Contingency or EDIA) Bare Tunnels (w/o Invert or Utilities)

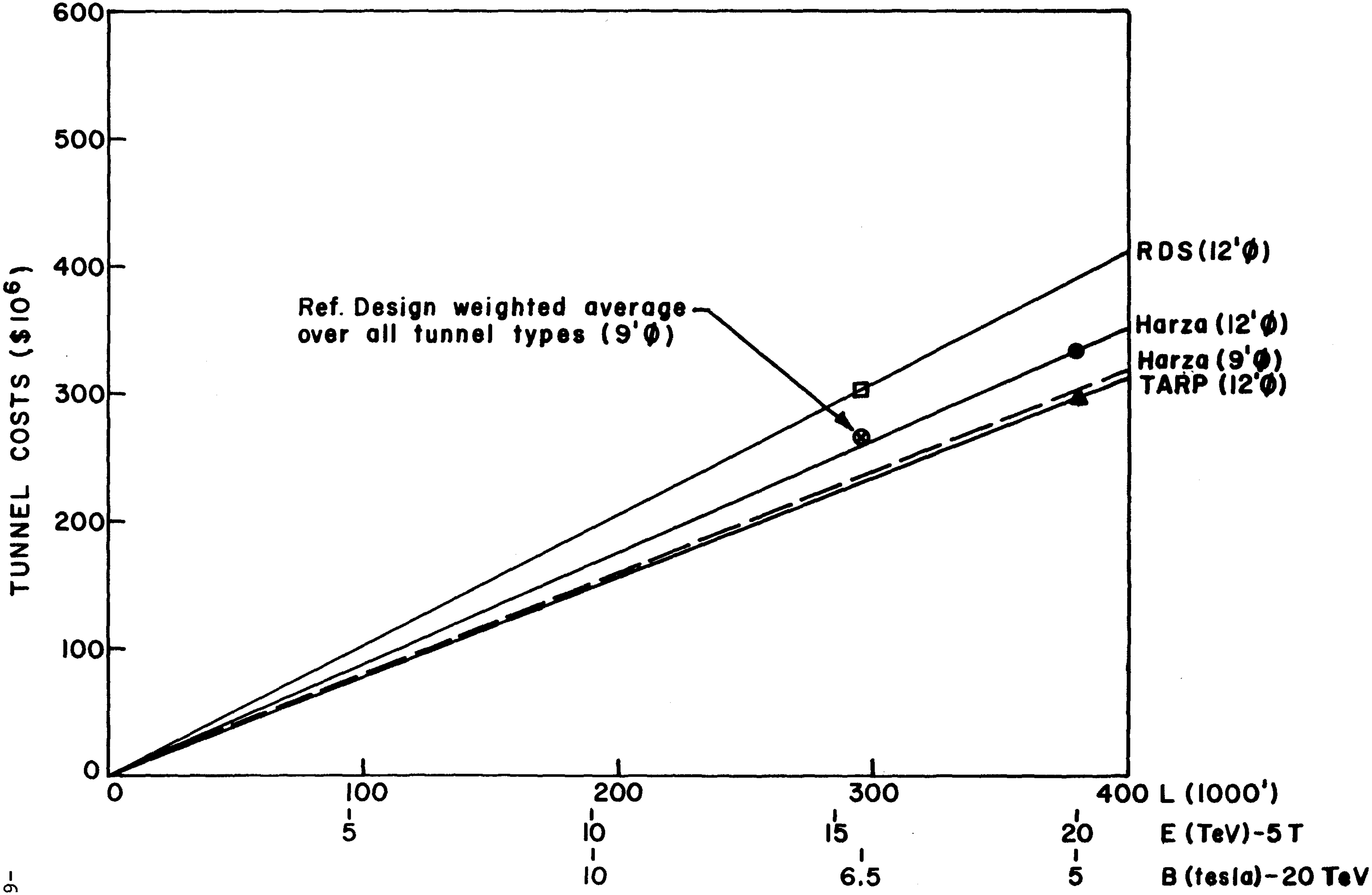

TABLE II

SSC COMPARATIVE TUNNEL COSTS
(w/o Contingency or EDIA)

I. Rock Tunnels (no invert)

1. Reference Design (12'Ø sandstone/limestone)

| | |
|---|---|
| Unit cost - | $1033/ℓ.f.[1] (from PB backup detail) |
| Magnetic field - | 6.5T |
| Length - | 205,152 ft.[2] |
| (Invert cost - | $ 60/ℓ.f. ) |

2. Harza (12'Ø dolomite)[3]

| | |
|---|---|
| Unit cost - | $ 879/ℓ.f. |
| Magnetic Field - | 5T |
| Length - | 380,000 ft |
| (Invert cost - | $ 243/ℓ.f. ) |

3. Harza (9'Ø dolomite with notches)

| | |
|---|---|
| Unit cost - | $ 794/ℓ.f. (778+16 for notches) |
| Magnetic field - | 5T |
| Length - | 380,000 ft |
| (Invert cost - | $ 230/ℓ.f. ) |

4. TARP Experience (12'Ø dolomite)

| | |
|---|---|
| Unit cost - | $ 775.17/ℓ.f.[4] |
| Magnetic field - | - |
| Length - | 18,260 ft |
| (Invert cost - | - ) |

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[1] T.E.Toohig memo, January 3, 1985.

[2] RDS Conv. Fac., p. IV-66.

[3] Harza Report, February 1985, Prd. Estimate 7, October 4, 1984.

[4] TARP Handout, January 29, 1985.

TABLE II



SSC COMPARATIVE TUNNEL COSTS
(w/o Contingency or EDIA)

II. Mixed Tunnel - Reference Design[1] (no invert)

| | | | |
|---|---|---|---|
| Type I: Rock (12'Ø with partial 1' lining) | | | |
| Shale: | 31,680' @ $940/ℓ.f. + 25% lining | | $1096/ℓ.f. |
| Hard rock: | 31,680' @ $1090/ℓ.f. + 10% lining | | 1163/ℓ.f. |
| Type II: Soft ground tunneling (11'Ø with 6" precast lining) | | | |
| Clayey silt: | 69,168' | | $1012/ℓ.f. |
| Type III: Cut-and-Cover (9' ID precast hoops) | | | |
| Shale: | 28,512' | | $ 643/ℓ.f. |
| Transition: | 22,176' | | 877/ℓ.f. |
| Stiff clay: | 44,880' | | 848/ℓ.f. |
| Transition: | 22,176' | | 761/ℓ.f. |
| Till: | 22,176' | | 662/ℓ.f. |
| Transition: | 22,704' | | 677/ℓ.f. |
| | 162,624' | Average | $ 755/ℓ.f. |
| | 295,152' | Average Cost | $ 896/ℓ.f. |

[1]SSC Cost Estimate Backup, Book 3.