**Use of Single Channel Carrier**

**to Defer Feeder Relief Project**

**Solution of Case Study**

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## 1. Evaluation of *pvf*

1.1 Cable

$\mu$ includes charges due to infinite replacement because of service life plus maintenance and operating costs.

$\hat{\mu}$ includes charges only due to infinite replacement.

$$\mu_c = 1 + \frac{1}{(1+i)^{Tc} - 1} + \frac{U_c}{i} = 1 + \frac{1}{1.1^{35} - 1} + \frac{0.025}{0.1} = 1.287$$

$$\hat{\mu}_c = 1 + \frac{1}{(1+i)^{Tc} - 1} = 1.037$$

1.2 *SCC*

$$\mu_s = 1 + \frac{1}{(1+i)^{Ts} - 1} + \frac{U_s}{i} = 1.815$$

$$\hat{\mu}_c = 1 + \frac{1}{(1+i)^{Ts} - 1} = 1.315$$

## 2. Evaluation of costs

2.1 Cable

2.1.1 *Basic total cost*

$A$ = [(purchasing cost) $\mu_c$ + (digging & placement cost) $\hat{\mu}_c$ ] $\lambda$

$$= [100 \cdot 1.287 + 650 \cdot 1.037\,]4 = 3212\,MU$$

Incremental total cost

$B$ = (purchasing cost) $\mu_c \lambda = 6.5 \cdot 1.287 \cdot 4 = 33.5\,MU\,/\,pair$

2.2 *SCC*

Total cost $\Gamma$ = purchasing cost $\cdot \mu_s$ + (installation + removal) $\hat{\mu}_s = = 30 \cdot 1.815 + 10 \cdot 1.315 = 67.6\,MU\,/\,piece$

Annual charges $\gamma = i\Gamma = 0.1 \cdot 67.6 = 6.76\,MU\,/\,piece\,/\,year$

## 3. Evaluation of parameters

$$r = \lambda n(1+i) = 0.095$$

$$G = \frac{rA}{\gamma\lambda} = \frac{0.095 \cdot 3212}{6.76 \cdot 15} = 3.014$$

$$H = \frac{rB}{\gamma\lambda} = \frac{0.095 \cdot 33.5}{6.76 \cdot 15} = 0.0314$$

$$Y = \frac{\lambda}{r} = \frac{15}{0.095} = 157.9$$

$$Z = \frac{\gamma}{rB} = \frac{6.76}{0.095 \cdot 33.5} = 2.124$$

**4. Evaluation of optimal capacity expansion and PW (all cable solution)**

$$P = \frac{Ar}{B\lambda} = \frac{3212 \cdot 0.095}{33.5 \cdot 15} = 0.607$$

$$S = \frac{\lambda}{r} \lambda n\left(1 + P + \sqrt{2P}\right) = 157 = 150\, pairs$$

$$PW = \frac{A + BS}{1 - e^{-rS/\lambda}} = \frac{3212 + 33.5 \cdot 150}{1 - e^{-0.095 \cdot 150/15}} = 13430\, MU$$

**5. Evaluation of relief time *T* and optimal capacity expansion (Temporary use of SCC)**

Using values of the parameter evaluated in the previous paragraphs, the following table is elaborated, giving the approximations for *T* and *S*. The iterative procedure stopped when two consecutives values for *S* differed less than one pair.

The algorithm used is the following:

$$T = G + HS, \qquad S = Y\lambda n[Z\left(e^{rT} - 1\right) + 1]$$

Initial guess for *S* to start the procedure has been used the optimal capacity for all-cable solution.

$S_o = 150\, pairs$

| Iteration | Capacity S | Time T |
|---|---|---|
| 1 | 150 | 7.70 |
| 2 | 188 | 8.89 |
| 3 | 213 | 9.67 |
| 4 | 227 | 10.11 |
| 5 | 235 | 10.35 |
| 6 | 240 | 10.52 |
| 7 | 243 | 10.66 |
| 8 | 245 | 10.67 |
| 9 | 245 | 10.67 |
| Actual values | 250 pairs | 11 years |

**6. Evaluation of present worth of expenditures**

When temporary use of *SCC* is adopted, the present worth of expenditures is calculated by

$$PW = \frac{\frac{\lambda\gamma}{r}\left[\frac{1}{r}\left(1 - e^{-rT}\right) - Te^{-rT}\right] + (A + BS)e^{-rT}}{1 - e^{-rs/\lambda}}$$

For the actual values *S = 200, T = 9*, we get

$$PW = \frac{\frac{15 \cdot 6.76}{0.095}\left[\frac{1}{0.095}\left(1 - e^{-0.095 \cdot 11}\right) - 11e^{-0.095 \cdot 11}\right] + (3212 + 33.5 \cdot 11)e^{-0.095 \cdot 11}}{1 - e^{-0.095 \cdot 250/15}}$$

$$= \frac{1067.4[6.82 - 3.86] + 5235}{0.795} \Rightarrow PW = 9097\, MU$$

## 7. Optimal relief policy

7.1 Temporary use of *SCC* solution

Facilities needed will be provided for 9 years by means of *SCC*. At the end of the 9th year, all *SCC* will be removed and a relief cable of size *S 200* pairs will be placed. The present worth of expenditure is

$$PW = 9097\ MU$$

7.2 All-cable solution

The optimal relief cable is 150 pairs. The present worth is

$$PW = 13428\ MU$$

The temporary use of *SCC* provides savings over all-cable solution. Particularly, we have

$$savings = (13428 / 9097.1)100 = 47.8\%$$

We can easily ascertain that temporary use of *SCC* ensures significant economy.

7.3 Permanent use of *SCC*

The present worth for permanent *SCC* solution is given approximately by

$$PW = \int_o^\infty \lambda\ \gamma\ \ te^{-rt} = \frac{\lambda\ \gamma}{r^2}$$

which, for our examples, becomes

$$PW = \frac{15 \cdot 6.76}{0.095^2} = 11235\ MU$$

Therefore, permanent use of *SCC* proves in by *2193 MU* over all-cable solution.

Thus, temporary *SCC* must always be considered even for long routes where permanent *SCC* proves in.