# REHABILITATION OR RECONSTRUCTION OF ROAD BRIDGES: HOW TO SELECT THE MOST SUITABLE SCENARIO?


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# *A COMMON BRIDGE*

- Multispan concrete girder bridge
- 40 years
- The girder is made of post-tensioned concrete beam.

# *WITH SOME DEFAULTS*

- De-icing salt ingress in the post-tensioning ducts
- The grouting has been polluted by chlorides

The investigations (opening on the cables) shows:

- Good injection
- Very light corrosion of the wires
- Chloride content up to 0.5 % >> 0.07 %

  (Cl mass/grouting mass – acid extraction)

# *WHAT TO DO ?*

| | |
|---|---|
| SCENARIO 1 | The superstructure (girder and slab) is rebuild now |
| SCENARIO 2 | We make a moderate slab rehabilitation now<br>and<br>the superstructure will be rebuild in 20 years |
| SCENARIO 3 | We reinforce the girder (fiber-reinforcement) in order to maintain the bridge up to the end of his presume initial timelife : 100 years |

# *HOW TO SELECT THE BEST REHABILITATION METHOD ?*

- Daily question for a bridge manager
- Answer :

- PIARC – Road Bridge Technical committee :
  - ➢ Issue : Technical and economic considerations of bridge rehabilitation methods
    - o How to compare different rehabilitation methods ?

# *State of the art*

- Bridge management in Europe (BRIME) – 2001
- Most countries :

  No specific tool to determine whether a structure should be repaired or replaced except Denmark, USA and Finland

- BRIME :
  - ✓ Determine a global cost analysis C (many different kind of costs)
  - ✓ Minimize C while keeping the failure probability during all the lifetime below an acceptable value
  - ✓ Repair index : RI = C alternative solution / C reference solution

# *PIARC QUESTIONNAIRE*

- Answers from 17 countries
- Most countries : no specific tool to compare rehabilitation methods (like BRIME 2001)
- *TECHNICAL MEETINGS*
- *BY COMPARING SOLUTIONS ONLY COST AT PRESENT TIME*
- *USING A PROCEDURE BASE ON A LIFE CYCLE ANALYZE PERFORMED ON AN ANALYSIS PERIOD (CANADA-ONTARIO)*

# *LIFE CYCLE ANALYSIS*

- During all a period (analysis period) : … 60 … 100 … years
- Determine different kinds of cost :
  - ✓ Works
  - ✓ User cost
  - ✓ Environnemental
  - ✓ …

# *PIARC DECISION PROCESS PROPOSAL*

- Base on:
  - ✓ All answers
  - ✓ The state of the art
  - ✓ Internal discussion
- Goal:
  - ✓ Introduce this decision process in a Global bridge stock rehabilitation process
  - ✓ Produce an annual rehabilitation program
  - ✓ For each bridge the most suitable rehabilitation solution

# *DETAILED PROCESS*

- Explained in the final report (PIARC - 2019)
- Focus : Rehabilitation methods comparison
- Prioritization process

# *COMPARISON PROCESS*

- Differents scenarios on an identical analysis period

# *COSTS*

- For each step :
  - ✓ Rehabilitation/maintenance cost
  - ✓ User cost (delay due to traffic congestion)

- User cost >> works cost (3-4 X)

- Present time cost

# *PRESENT TIME COST*

A cost in the future must be calculate at present time

Discount rate

$$P = C_n / (\ 1 + R\ )^n$$

Where:

P : Cost at present time

$C_n$ : Cost in n years

r : discount rate

n : time of the works

# *COST IN THE FUTURE*

Base on today cost

Inflation

$$C_n = C_0 ( 1 + i )^n$$

Where:

$C_n$ : Cost in n years

$C_0$ : Cost today

i : inflation rate

n : time of the works

# *COMPARAISON – NET PRESENT VALUE*

For each rehabilitation method :

- All cost (works and user) during the analysis period at present time = Net Present Value (NPV)

- Select the method with min NPV

# *COMPARAISON – BENEFIT/COST RATIO*

- Select the less expensive method = base option
- Benefit $B_{jo}$: Benefit of scenario j comparing to scenario o

$$B_{jo} = ( TI_o – TI_j ) + ( RV_j - RV_o )$$

$TI_i$: Traffic impact of scenario i

$RV_i$: residual value of the bridge at the end of the analysis period for scenario i

# *COMPARAISON – BENEFIT/COST RATIO*

$$B_{jo} / ( C_j - C_o )$$

< 1 : scenario j is not suitable comparing to scenario o

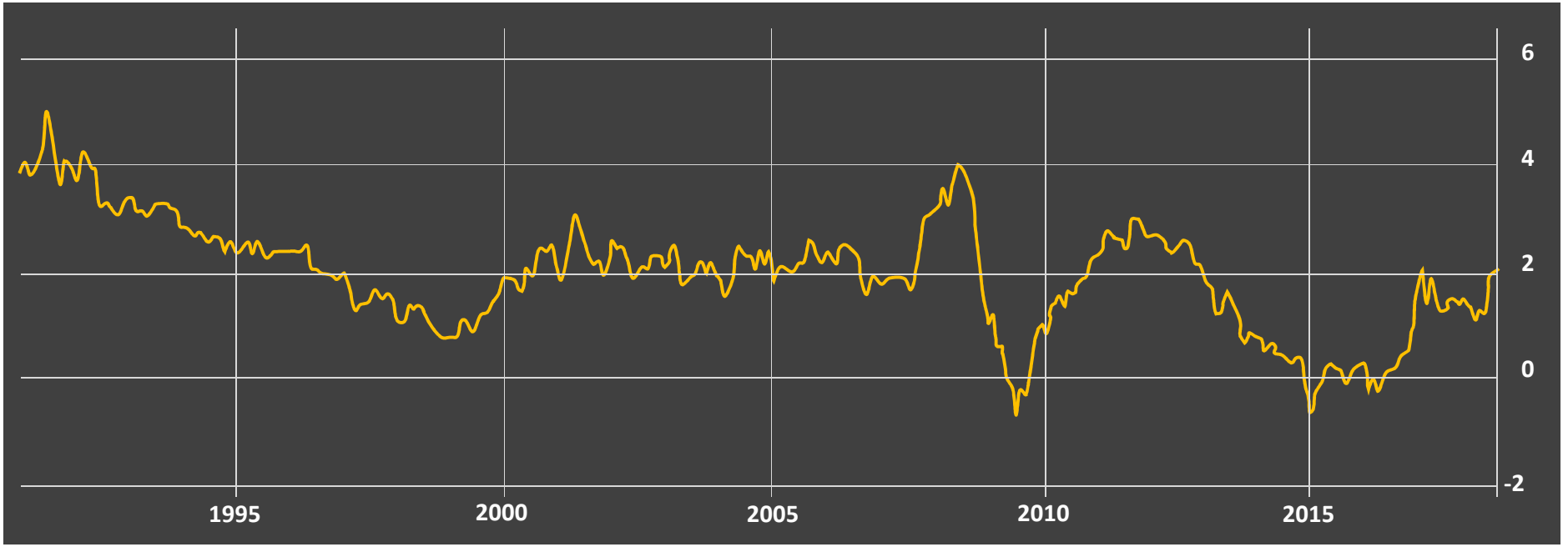
> 2 : scenario j is highly suitable comparing to scenario o

1 – 2 : there is a little advantage in scenario j

! Uncertainties

# *UNCERTAINTIES*

- Inflation rate - Actually about 1 %



# *UNCERTAINTIES*

DISCOUNT RATE

**FRANCE**

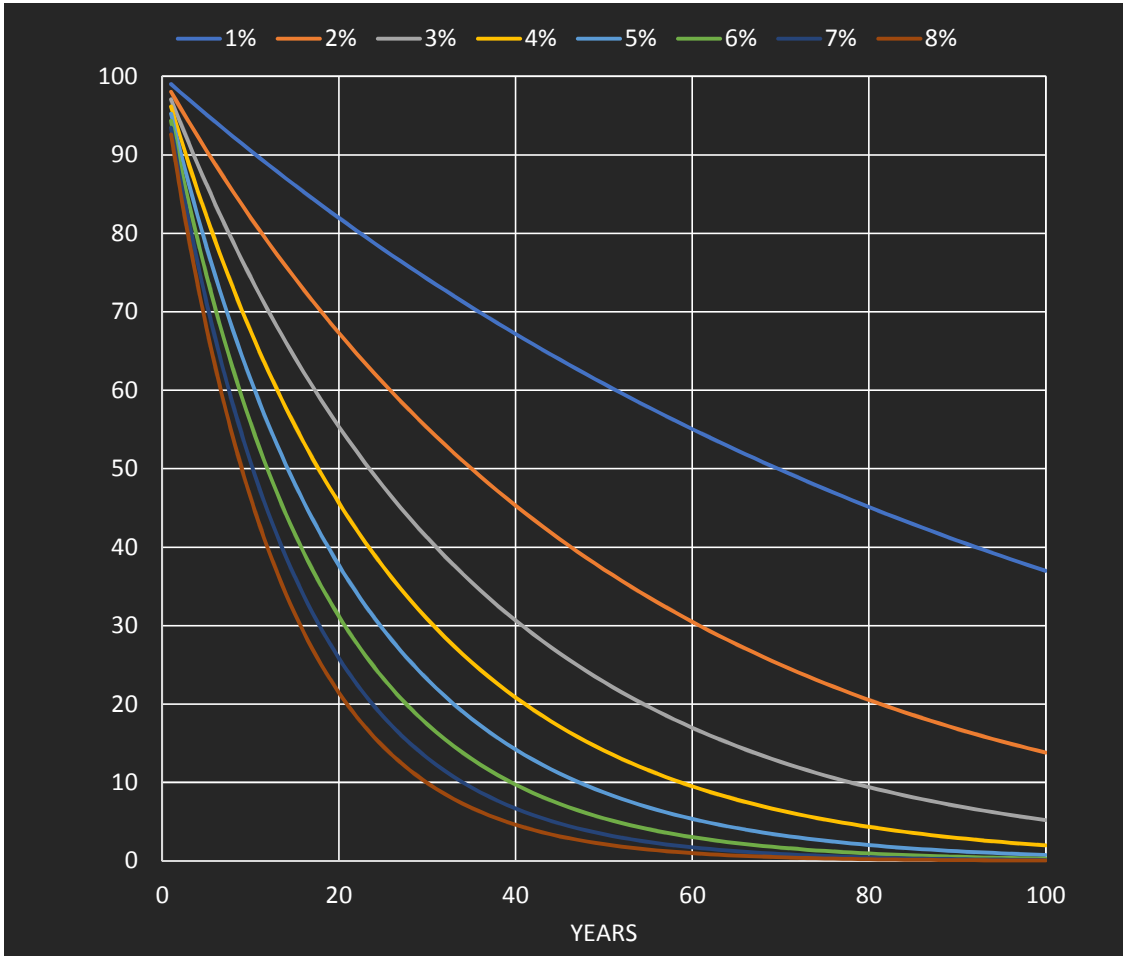
8% until 2005
Actually it is fixed to 4%

**UK**

3.5 %
Some propose to use a decreasing rate from 3% after 30 years to 1% over 300 years

**USA**

It is recommended to apply two discount rates : 3 % and 7 %.



# *UNCERTAINTIES*

- Base on a maintenance program during all the analysis period.
- Will it be respected during all the analysis period ?
- See our actual bridges build 50 years ago !

# *HOW TO MANAGE THOSE UNCERTAINTIES ?*

- Repeat the comparison process with
  - ✓ Different analysis period
  - ✓ Discount rate
  - ✓ Maintenance program

# *CONCLUSION*

- This process is for high importance project
- For medium importance project :

  COMPARE ONLY THE COSTS AT PRESENT TIME (WORKS, USERS)

- For low importance project

  ENGINEERING JUDGEMENT