OPTI 2005

Skiathos,Greece

Simulated annealing optimization of walls, portal and box reinforced concrete road structures

by

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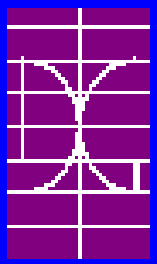
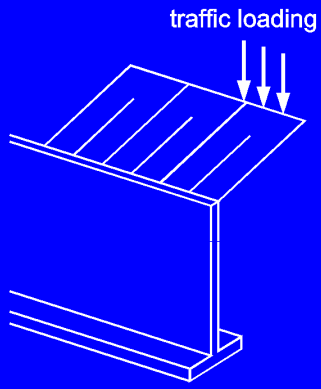


1. Structures object of the study.

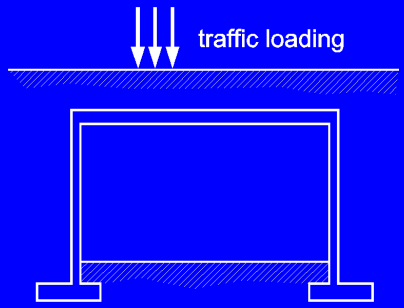
A) Cantilever RC earth retaining walls

(Internal Report CST/GPRC-01, Alcalá)



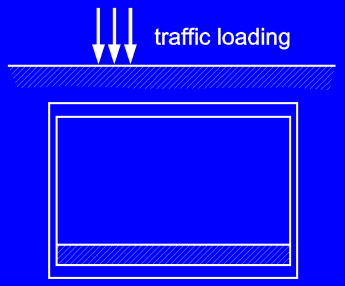
B) Portal RC road frames

(Internal Report CST/GPRC-02, Carrera)



C) Box RC road frames

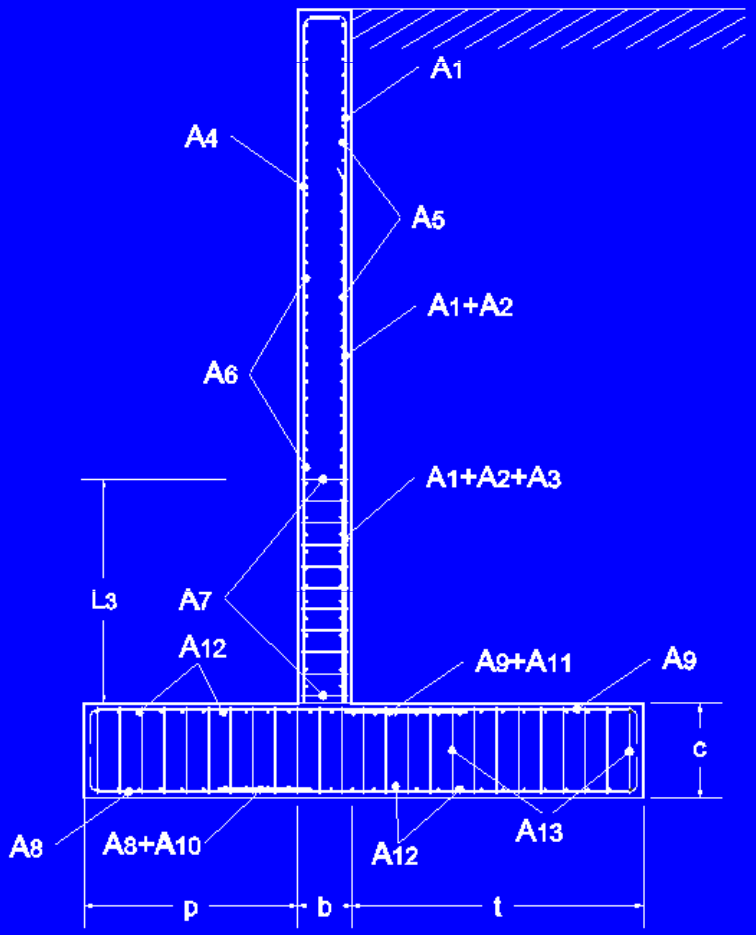
(Internal Report CST/GPRC-03, Perea)

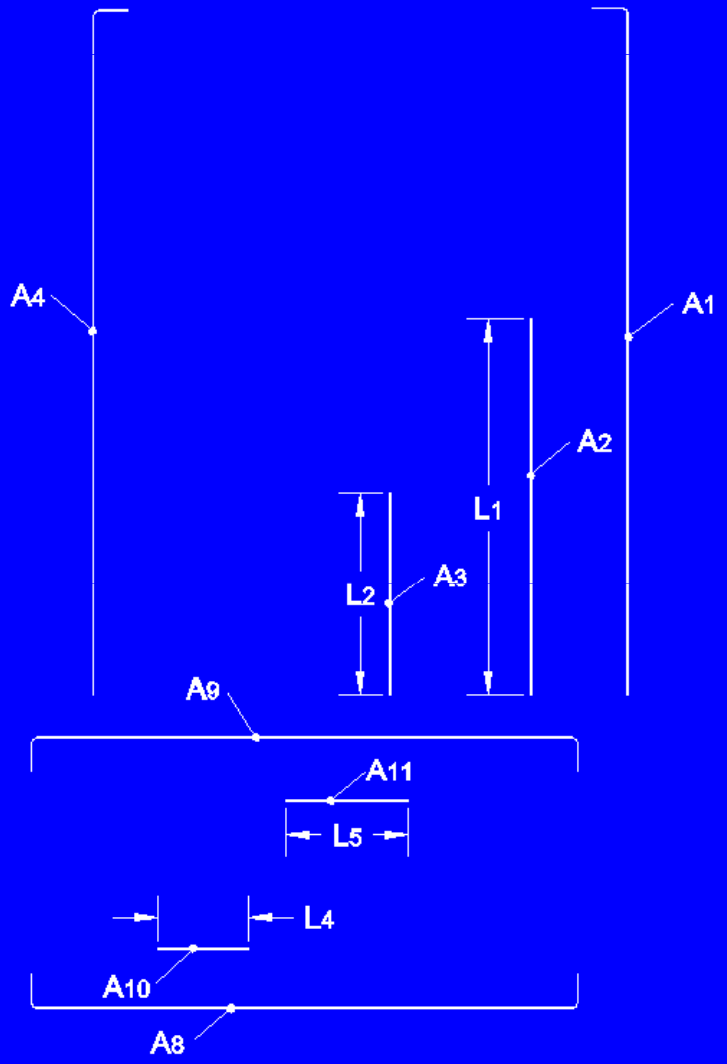


2. Variables and parameters.

2.1. Walls: 26 continuous and discrete variables:

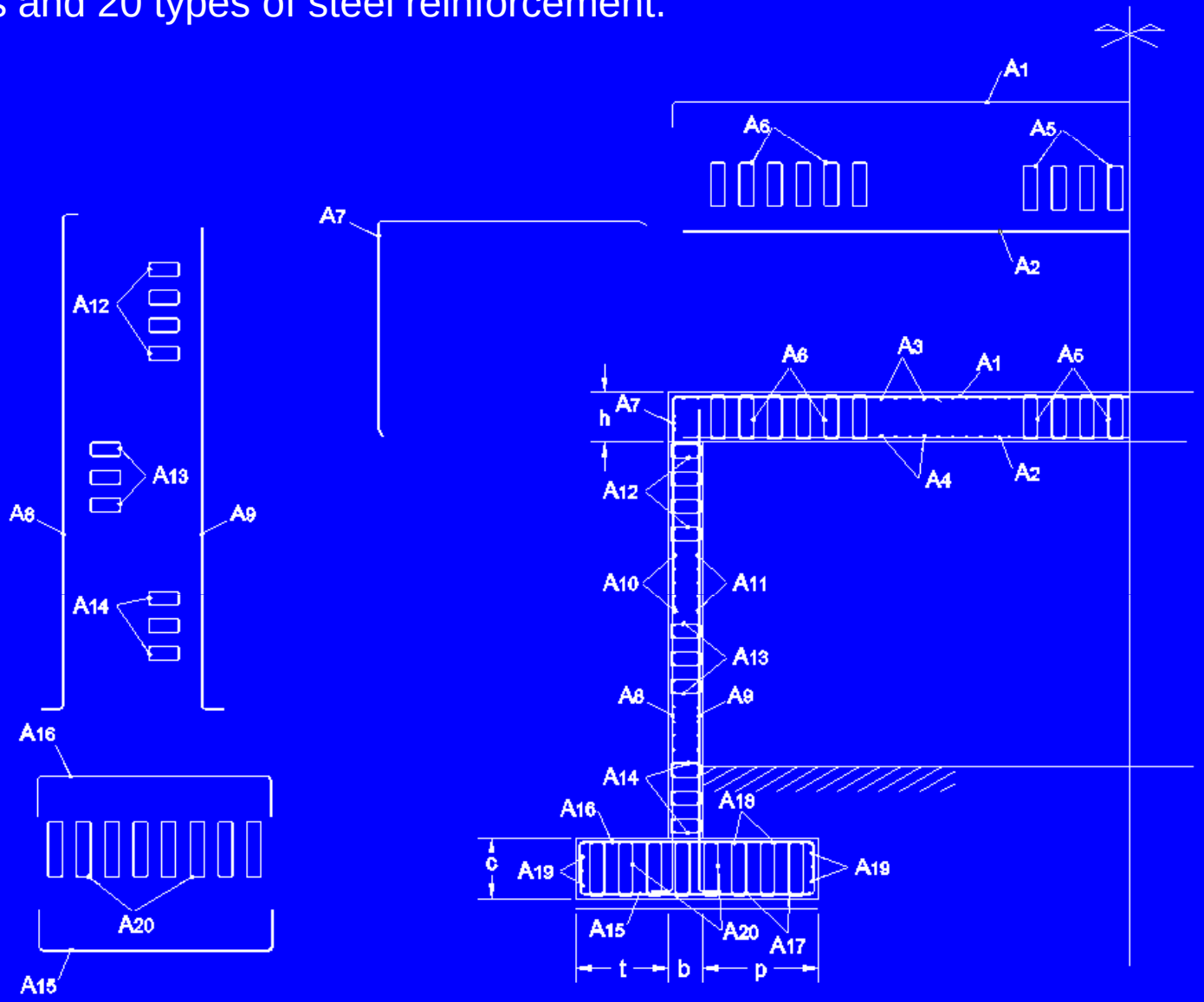
- 4 geometrical
- 4 concrete and steel grades
- 18 variables of steel reinforcement setup





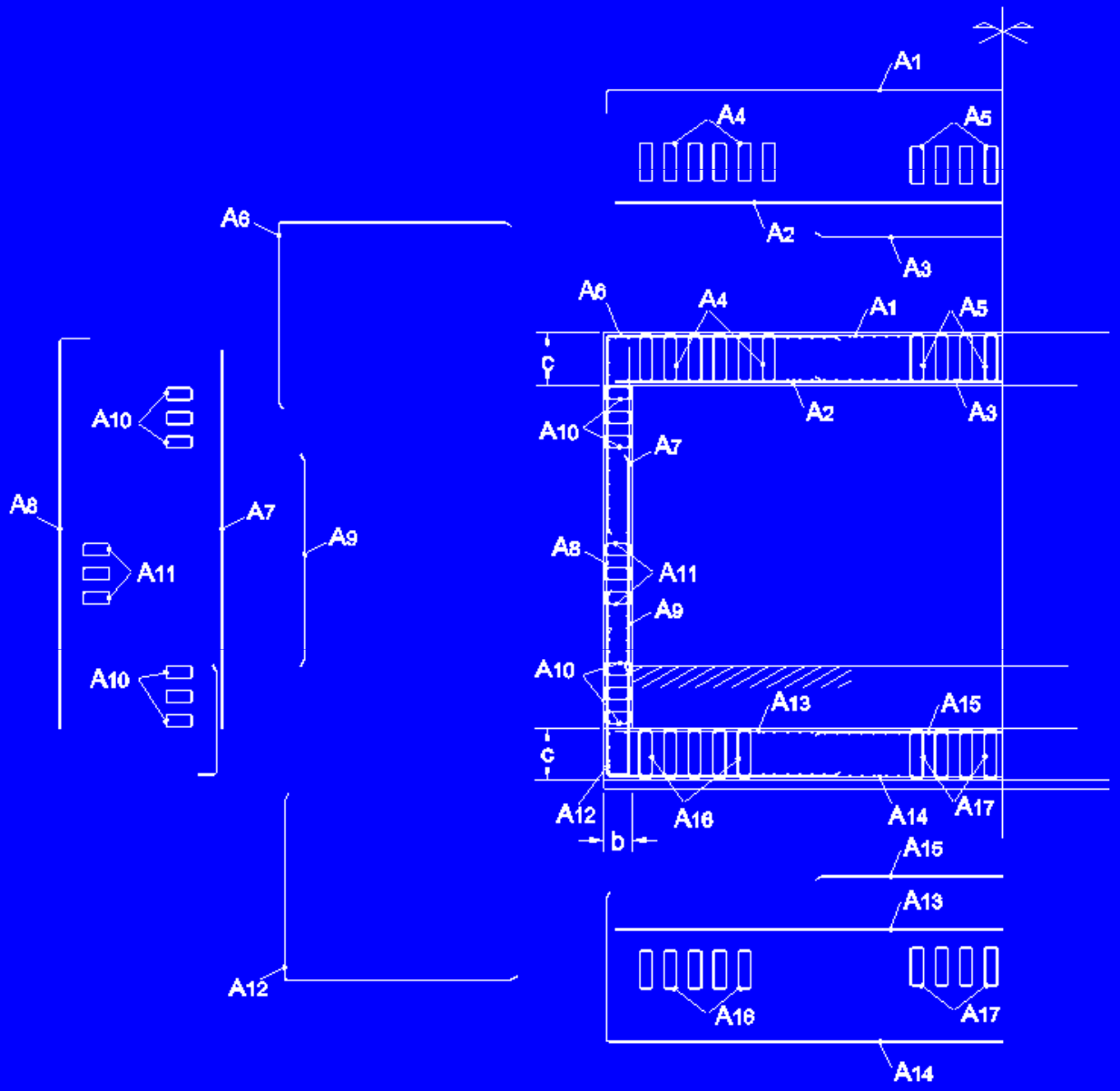
2. Variables and parameters.

2.2. Variables for the RC portal road frames: 28 variables; 5 geometrical, 3 concrete grades and 20 types of steel reinforcement.



2. Variables and parameters.

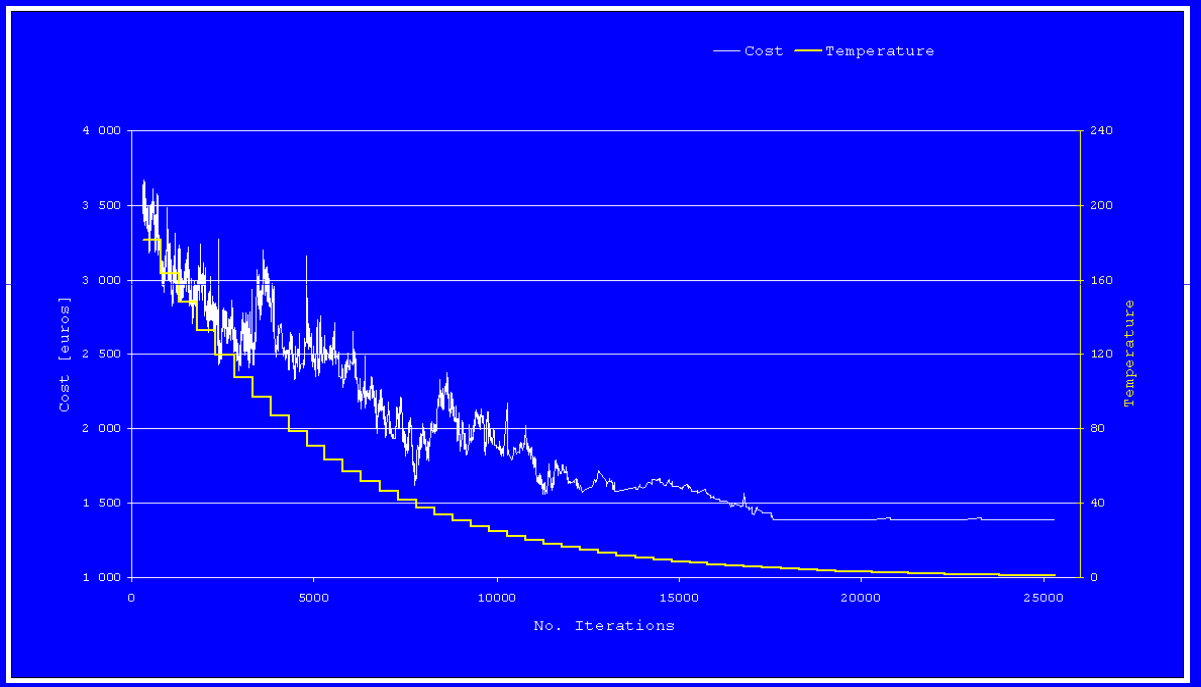
2.3. Variables for the box frame road structures: 44 variables: 2 geometrical, 2 concrete grades and 40 types of steel reinforcement.



3. Feasibility of solutions.

- Loads according to national IAP prescriptions for road bridges.
- ULS:
  - sliding and overturning (only walls)
  - flexure
  - shear
- SLS:
  - flexure (cracking control)
  - deflections:
    - 1/150 in walls
    - 1/250 for quasipermanent loading in frames
- Fatigue of concrete (box frames only)

4. Optimization procedure method.



SIMULATED ANNEALING:

$e^{-\Delta C/T}$ — Initial temperature (Medina)

Markov chains

$T_{i+1} = k\, T_i$ — Cooling coefficient

Methodology

step 1 – Generation of random solutions (random walk)

step 2 – Study of best moves by descent local search

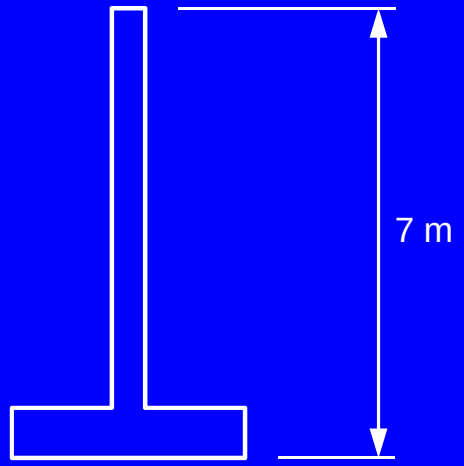
step 3 – Calibration of simulated annealing / threshold accepting methods

(9 runs per analysis: minimum, mean and standard deviation)

5. Results

5.1. Wall of 7.0 m height.

Variable	Permissible stress = 0.3 N/mm²		
	Reference	Deflections unrestricted	Deflections limited
b	0.25-0.70 m	**0.265 m**	**0.607 m**
p	0.75 m	0.833 m	0.770 m
t	1.70 m	1.248 m	0.900 m
c	0.70 m	0.568 m	0.605 m
$f_{ck,ste}$	25	35	30
$f_{ck,foo}$	25	25	25
$f_{yk,ste}$	500	500	500
$f_{yk,foo}$	500	500	500
A_1	7.70 cm²	**6.946 cm²**	**11.442 cm²**
A_2	7.70 cm²	**29.602 cm²**	**1.431 cm²**
A_3	0	**26.730 cm²**	**10.332 cm²**
A_4	4.35 cm²	1.000 cm²	1.149 cm²
A_5	3.74 cm²	3.400 cm²	6.552 cm²
A_6	7.73 cm²	5.661 cm²	13.120 cm²
A_7	0	0	0
A_8	13.40 cm²	16.837 cm²	16.958 cm²
A_9	10.05 cm²	1.000 cm²	17.013 cm²
A_{10}	0	19.549 cm²	1.000 cm²
A_{11}	0	1.447 cm²	1.000 cm²
A_{12}	3.74-1.67 cm² (low-up)	3.955 cm²	8.776 cm²
A_{13}	0	0	0
L_1	2.18 m	2.954 m	0.849 m
L_2	0	0.852 m	0.834 m
L_3	0	0	0
L_4	0	1.248 m	0.745 m
L_5	0	0.568 m	0.689 m



Simulated annealing data:

- Markov chains of 1000 iterations
- Cooling coefficient of 0.80
- Best move 16 in 26 variables
- Running time 21 minutes in Visual Basic 6.3 with an Excel I/O interface

Conclusion:

Importance of limitation of the deflection of the stem

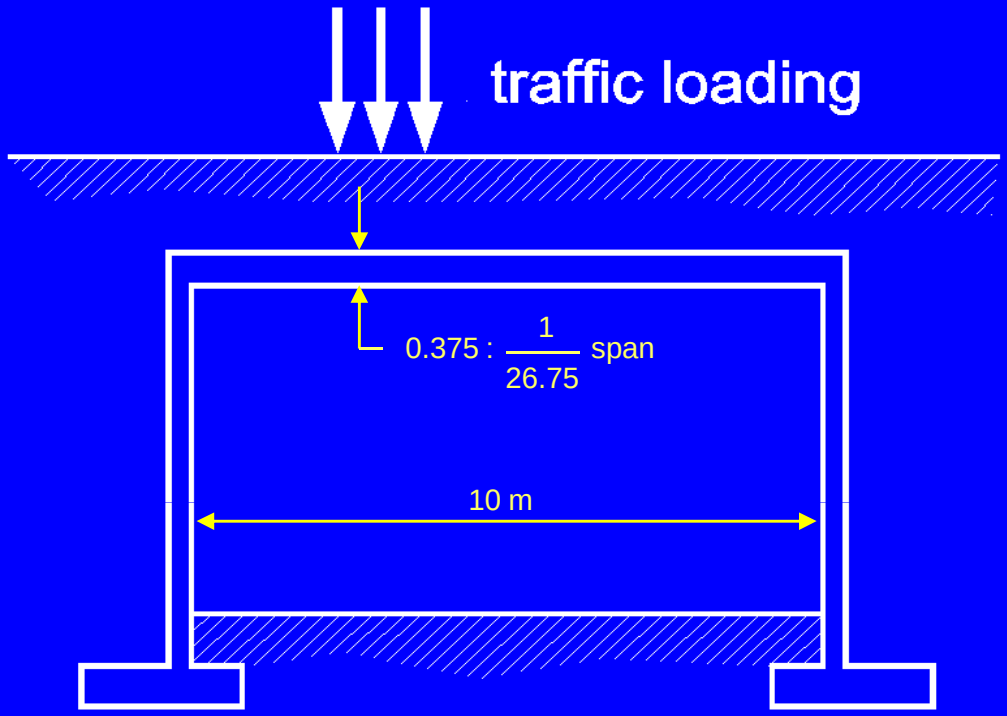
5. Results

5.2. Portal frame case study B.

Geometric variables	
h	0.375 m
b	0.400 m
c	0.400 m
p	0.950 m
t	0.750 m
Concrete grades	
upper slab	HA-25
wall	HA-25
foundation	HA-25
Reinforcement	
A_1	15ø12/m
A_2	10ø20/m
A_6	12.06 cm²/m
A_7	15ø12/m
A_8	8ø16/m
A_9	12ø8/m
A_{15}	10ø16/m
A_{16}	12ø10/m
A_{20}	9.05 cm²/m

Simulated annealing data:

- Markov chains of 375 iterations
- Cooling coefficient of 0.70
- Best move 4 in 28 variables
- Running time 10.75 hours in an AMD 1.49 GHz in Visual Basic 6.3



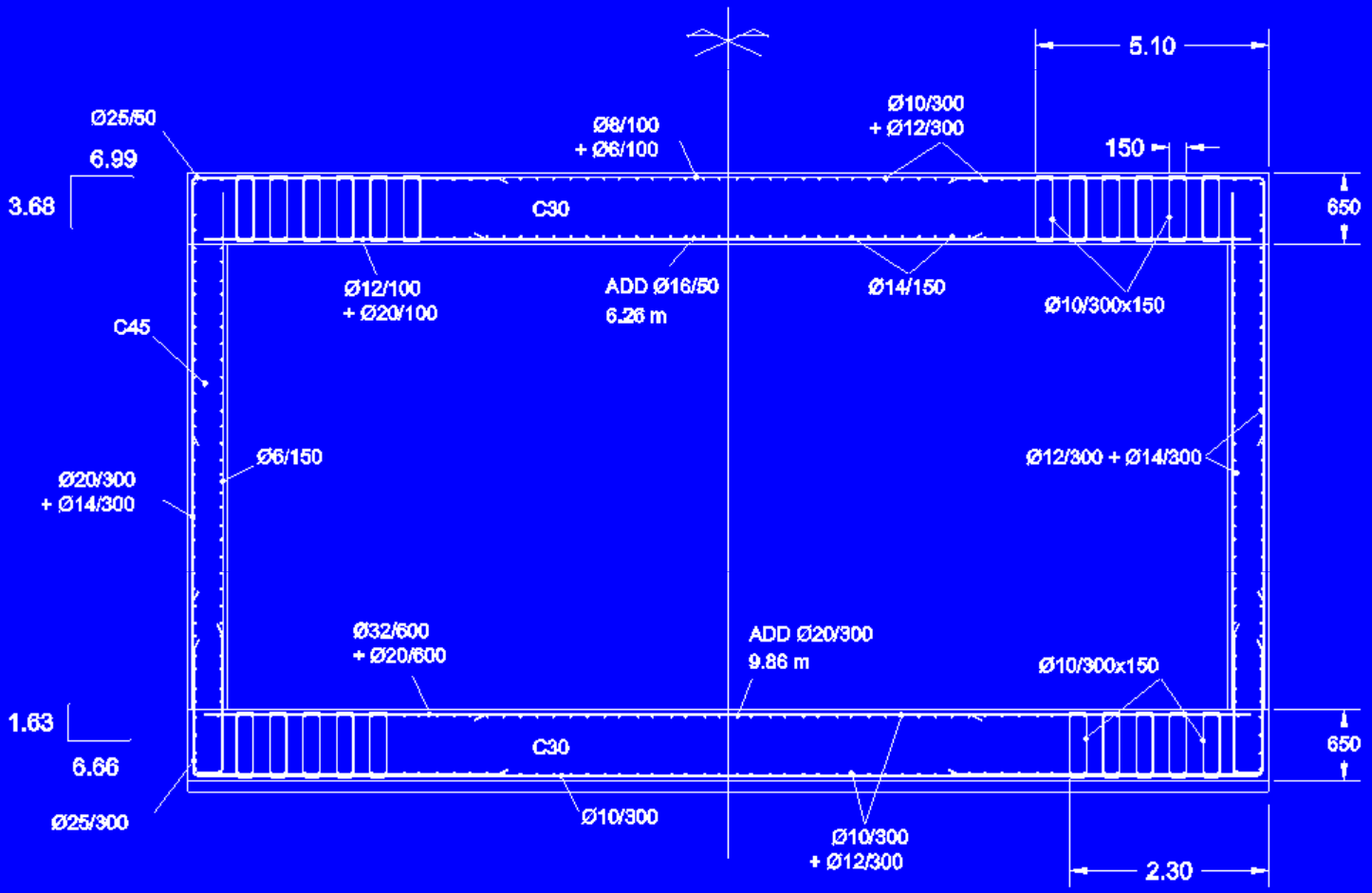
Conclusion: Importance of including fatigue of concrete.

5. Results

5.3. Box frame case study C.

Simulated annealing data:

- Markov chains of 500 iterations
- Cooling coefficient of 0.90
- Best move 9 in 44 variables
- Running time 47 minutes in an Pentium IV 2.40 GHz in Fortran



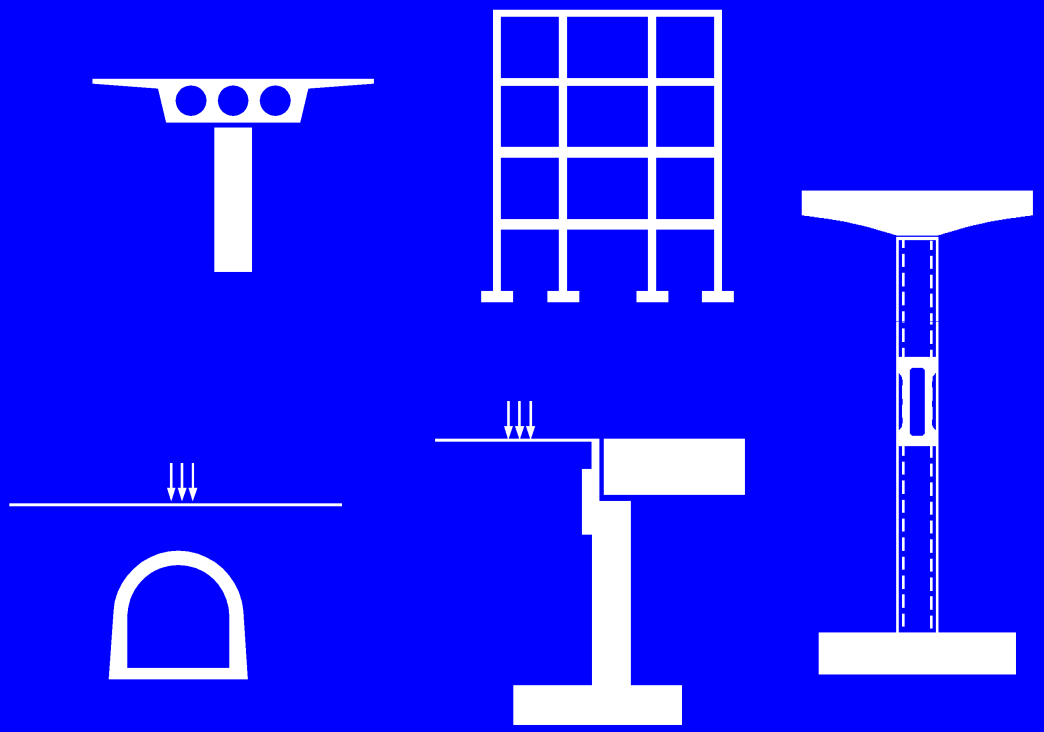
Conclusion: Importance of including fatigue of concrete and deflections.

7. Conclusions.

- Simulated annealing feasibility as an optimization procedure for RC road structures.
- Importance of limitting the deflections in wall analysis.
- Importance of deflections and fatigue of concrete in analysis of frame road structures.

8. Current and future work.

- Building frames
- Vaults
- Abutments of bridges
- Bridge hollow piers
- Prestressed concrete slab-decks for flyovers
- Composite decks for flyovers



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