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2000

CONFERENCE B5.1

LBR-5 A ship hull optimisation tool

P. RIGO *(ANAST - Université de Liège)*
A. HAGE *(ANAST - Université de Liège)*

SIMOUEST Marine 2000 – 29 & 30 November 2000

SIM OUEST

2000

29 & 30 Novembre / *November* 2000
NANTES / FRANCE

Lieu : Ecole Centrale de Nantes

ACTES DU CONGRES EUROPEEN
PROCEEDINGS OF THE EUROPEAN CONFERENCE

MARINE - Industrie & Simulation
MARINE TECHNOLOGY - Industry & Simulation

TOME 2 / *PART 2* : Salle B / *Room B*

Organisé par / *Organised by* :

ALSTOM DCN ECN SIRCA SIRIA Société d'Ingénierie Avancée

En Association avec / *In Association with* :

CS Communication & Systèmes — GE44 Pôle Atlantique de Génie Electrique

En partenariat avec / Sponsored by :

Région des Pays de la Loire — Loire Atlantique Conseil Général — District Agglomération Nantaise — ANVAR

JEUDI 30 NOVEMBRE 2000 /

THURSDAY 30TH NOVEMBER 2000

08:30 Accueil des participants /
Welcoming of the participants

09:00 Conférencier invité / Invited speaker : Dr ZARKA « **Intelligent optimal design of materials and structures** »

SESSION A4 : TRAINING HLA

<u>Jeudi / Thursday 9:30 – 10:20</u>

A4.1 **Adapting a bridge simulator to HLA - the challenges**
S. COTE (Norcontrol – Norway)

A4.2 **Building a Naval Combat System Simulation Environment with HLA**
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B. JAMES (DERA – Worcestershire)

A5.4 **Simulations and virtual reality visualisation for design and training**
P. BROAS J.MARTIO (VTT Manufacturing Technology – Finlande) / J. MATUSIAK / M. MAESALU (Technical University of Helsinki)

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B5.2 **Life-Cycle fatigue reliability of ship structures : an integrated approach**
S. V. PETINOV (Marine Technical University of St. Petersburg)

B5.3 **ALPS/ULSAP Software for Ultimate Strength Design of Steel Grillages under Combined Biaxal Compression/Tension, Biaxal Inplane Bending, Edge Shear and Lateral Pressure Loads**
J.K PAIK (Pusan National University – Korea) / O.F. HUGHES (Virginia Techn. – USA) / C. TODERAN / P. RIGO (ANAST – Université de Liège)

B5.4 **Fatigue analysis of high speed craft welded assemblies**
F. JANCART (IRCN – Nantes)

LBR-5, A SHIP HULL OPTIMIZATION TOOL

RIGO Philippe(*) & HAGE André

ANAST - University of Liege

(*) FNRS (National Fund of Scientific Research of Belgium)

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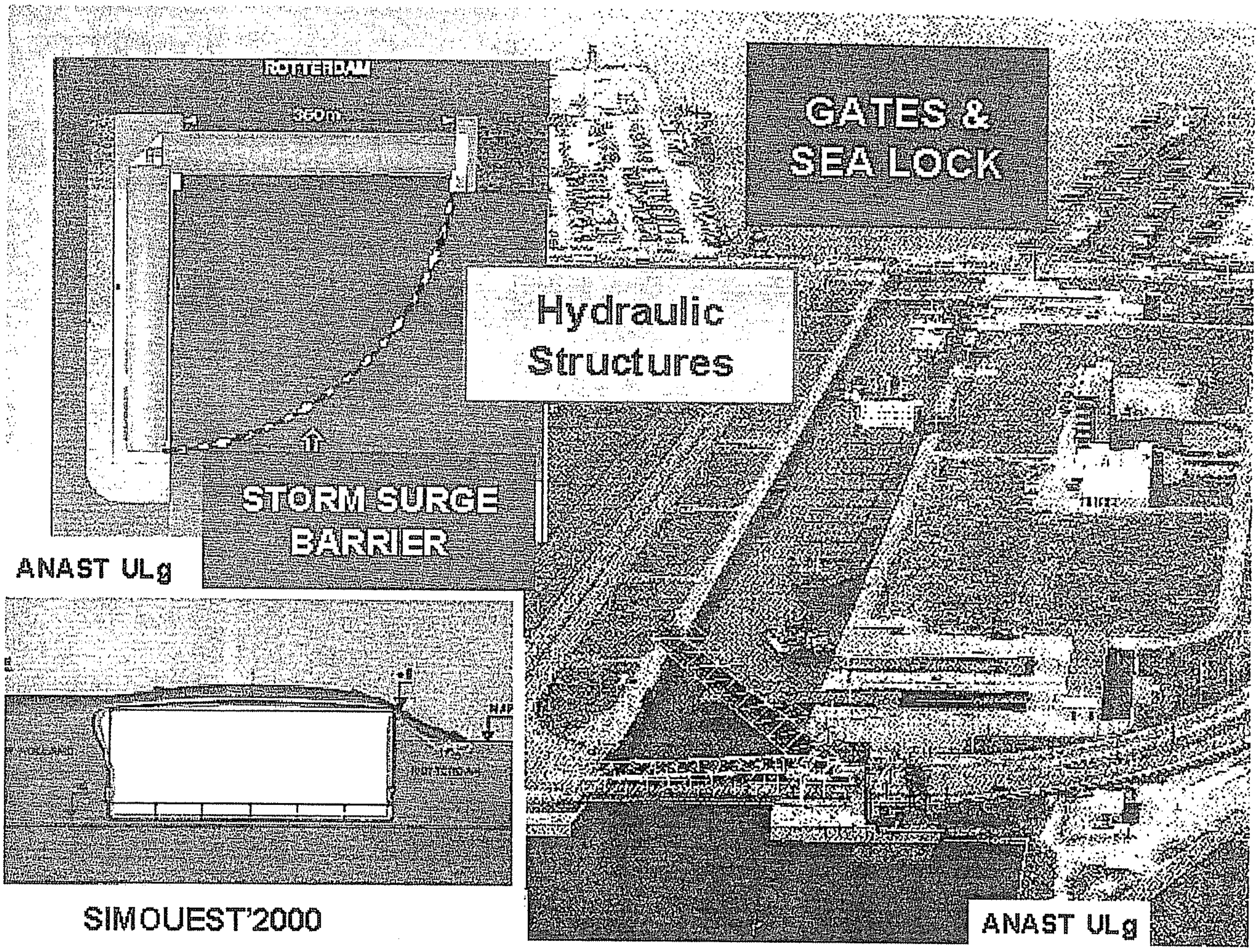
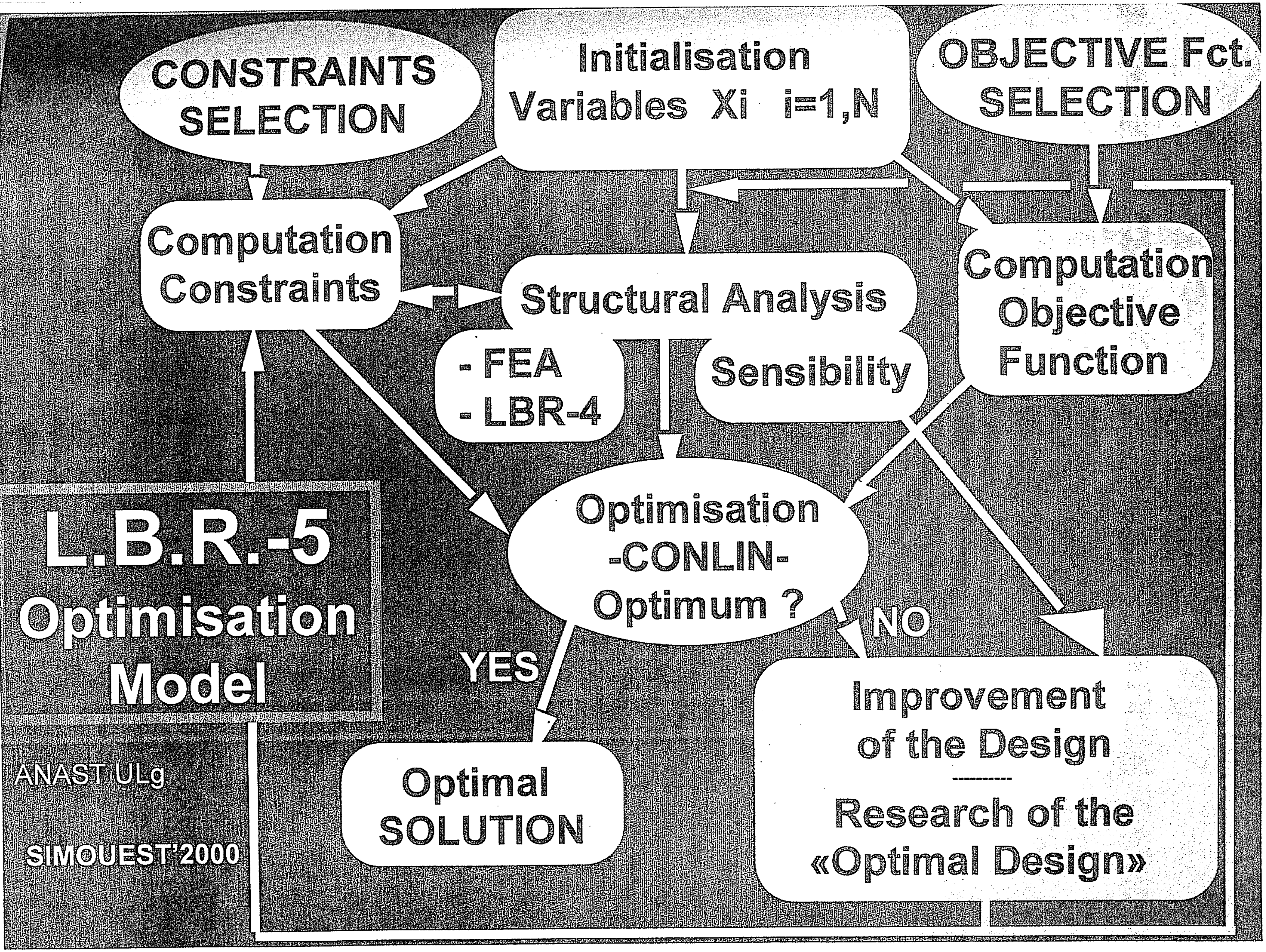
FIELD OF APPLICATIONS

SHIPS AND OFFSHORE STRUCTURES,

FLOATING STRUCTURES,

HYDRAULICS STIFFENED STRUCTURES in Civil Engineering.


ROTTERDAM
360m
GATES &
SEA LOCK
Hydraulic
Structures
STORM SURGE
BARRIER
ANAST ULg
SIMOUEST'2000
ANAST ULg



L.B.R.-5
Optimisation
Model
CONSTRAINTS
SELECTION
Initialisation
Variables Xi i=1,N
OBJECTIVE Fct.
SELECTION
Computation
Constraints
Structural Analysis
- FEA
- LBR-4
Sensibility
Computation
Objective
Function
Optimisation
-CONLIN-
Optimum ?
YES
NO
Optimal
SOLUTION
Improvement
of the Design
Research of the
«Optimal Design»
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MAIN COMPONENTS of an OPTIMISATION PROBLEM

- X_i $i = 1, N$ the N design variables

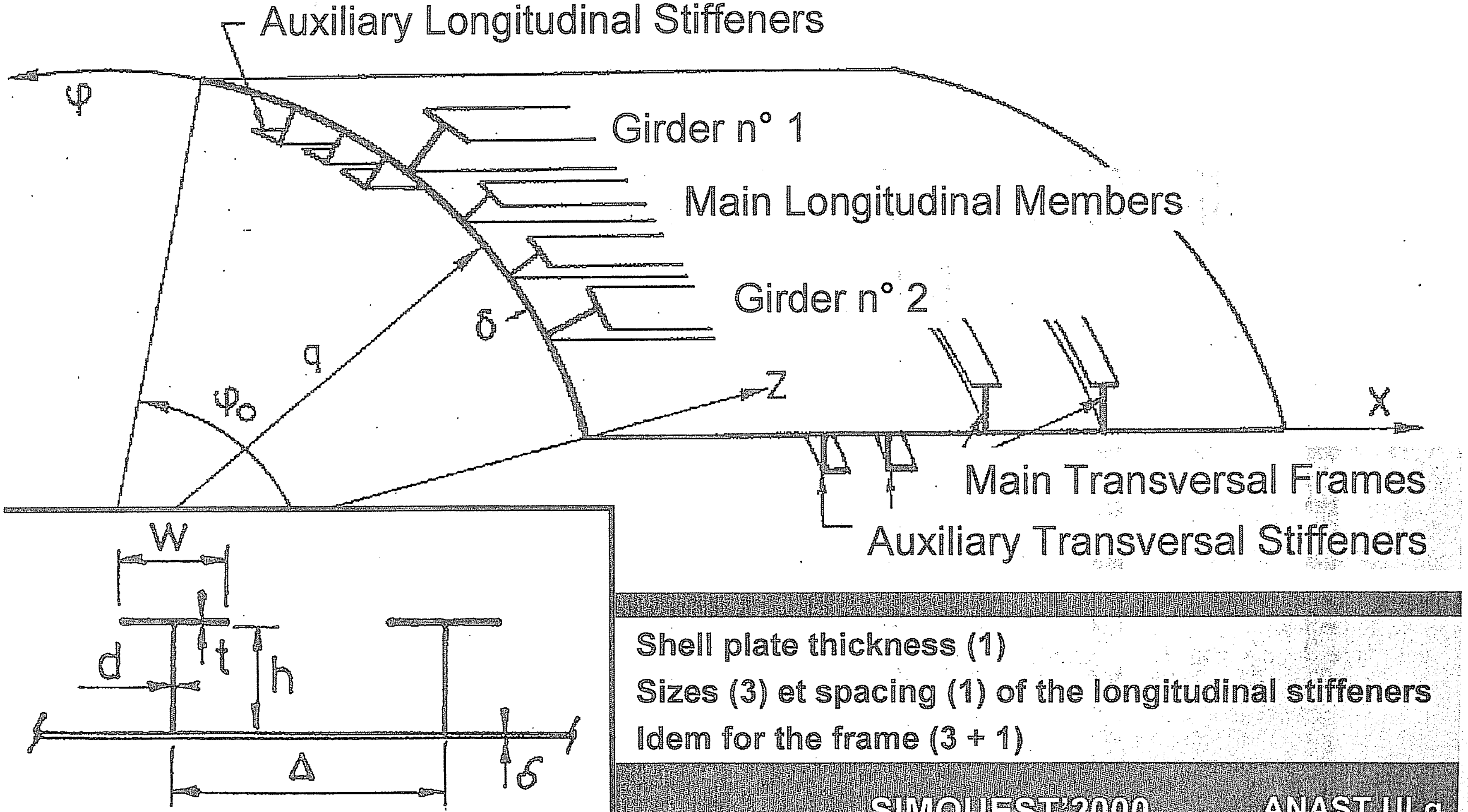
  with $X_{i\,min} \leq X_i \leq X_{i\,max}$ $i = 1,N$

- $F(X_i)$ the objective function to minimize,

- $C_j(X_i) \leq CM_j$ $j = 1,M$

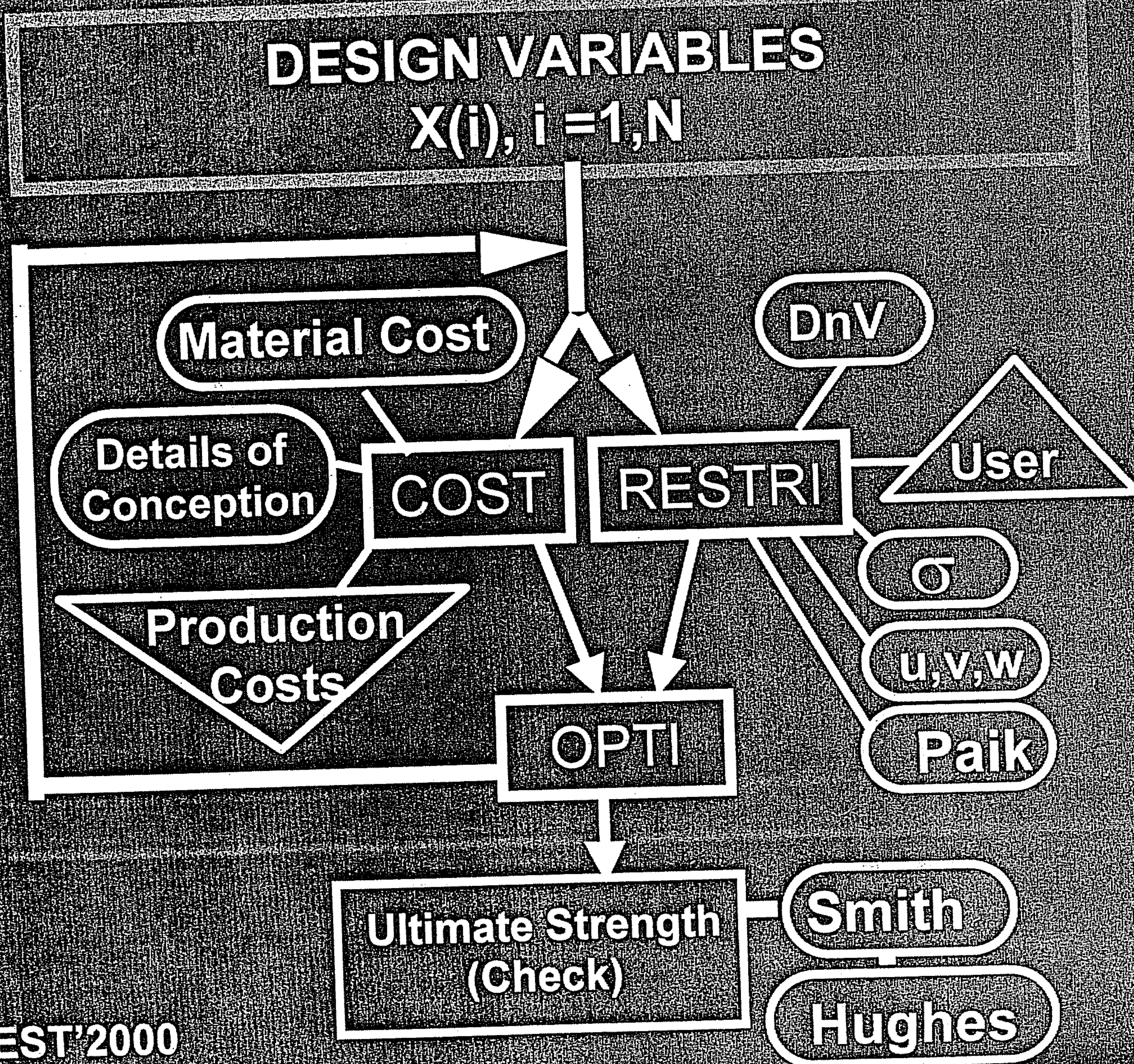
  with M1 structural constraints and
  M2 geometrical constraints

ELEMENT = STIFFENED PANEL
- 9 design variables -



Shell plate thickness (1)
Sizes (3) et spacing (1) of the longitudinal stiffeners
Idem for the frame (3 + 1)

FLOW CHART of L.B.R.-5



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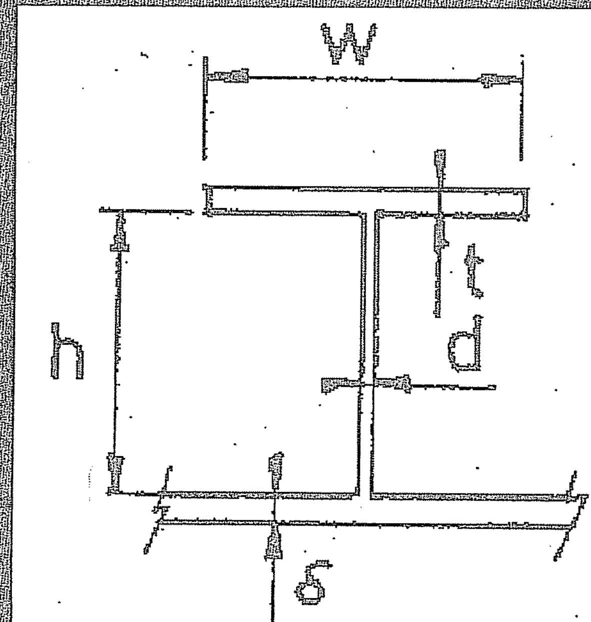
I. The CONSTRAINT Module

- Side Constraints : $X_{i\,min} \leq X_i \leq X_{i\,max}$
  - for each design variable
- GEOMETRICAL CONSTRAINTS
  - for each panel
- STRUCTURAL CONSTRAINTS
  - for each panel
  - for the global structure

I.1. GEOMETRIC CONSTRAINTS

- **Ratio web / flange :**
  $1,0 \leq h/w \leq 2,0$
- **Web Slenderness :**
  $h - 40\, d \leq 0$
- **Web/Plate Compatibility**
  $\delta - 2\, d \leq 0$
  (welding ability)



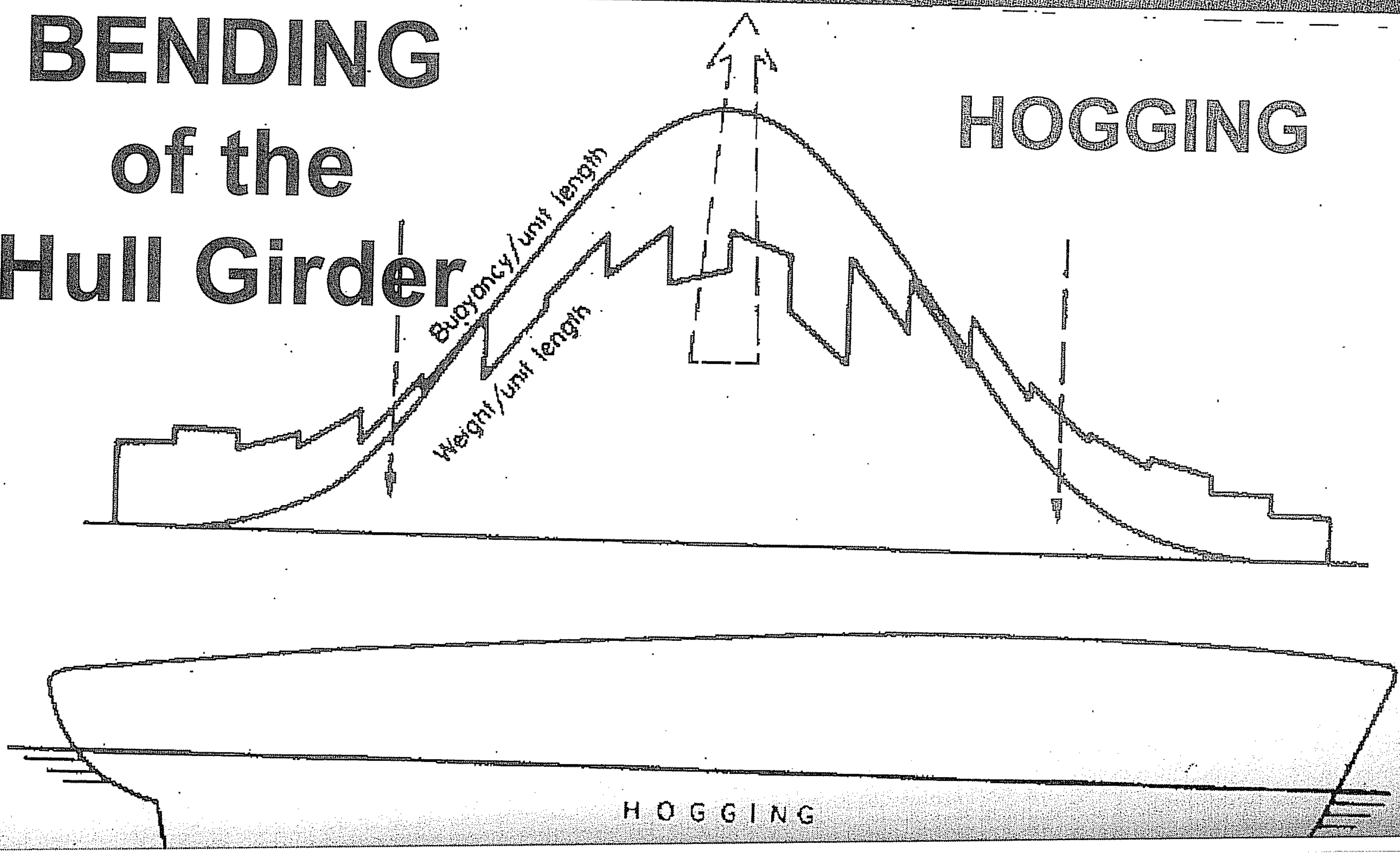
I.2. STRUCTURAL CONSTRAINTS

- CONCERNED ELEMENTS
  - Stiffened panels
  - Frames
  - Global structure
    (hull girder, caisson)
- LIMIT STATES
  - Serviceability
  - Ultimate Strength

I.2. STRUCTURAL CONSTRAINTS
- HULL GIRDER (caisson) -

BENDING of the Hull Girder

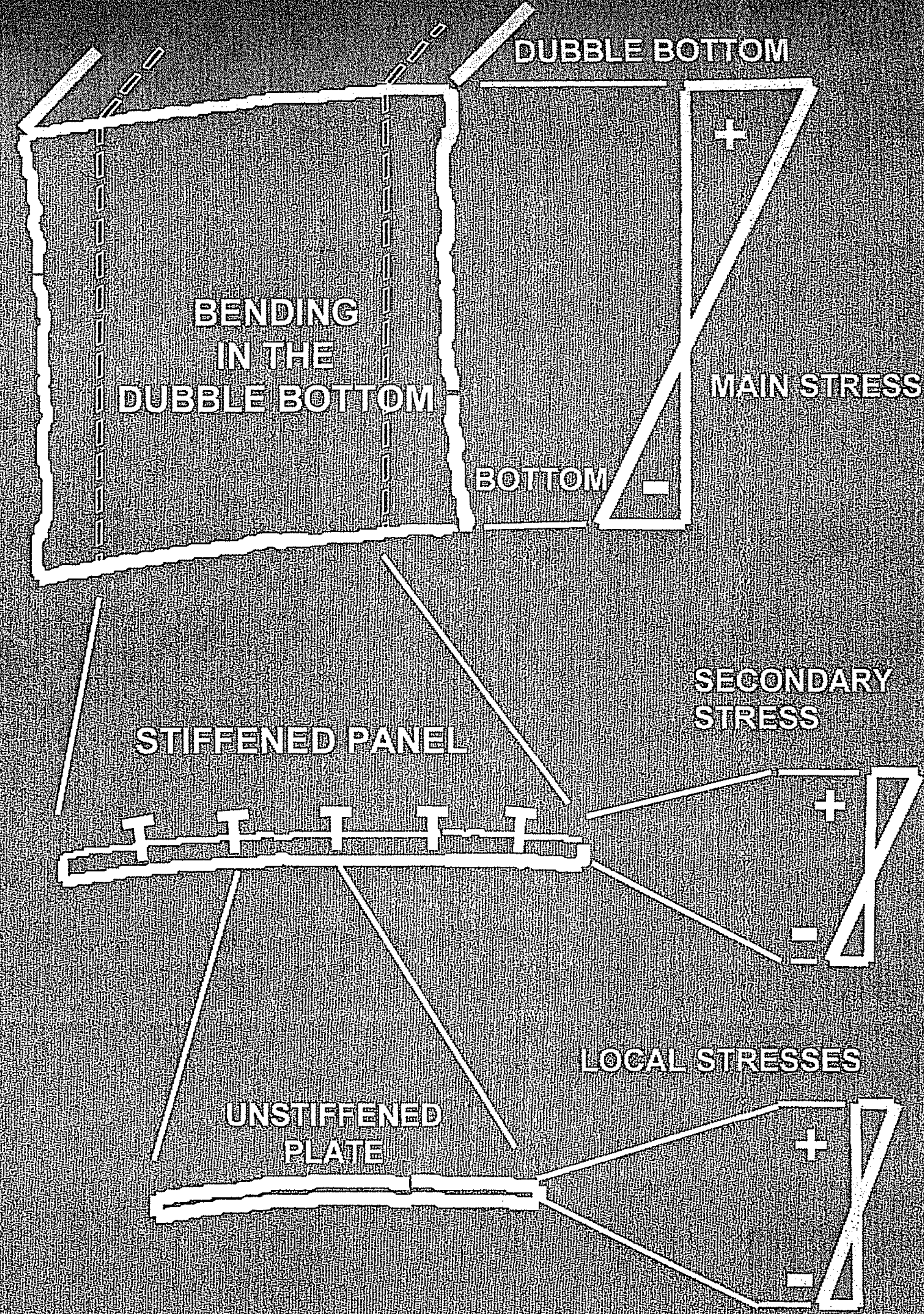
HOGGING



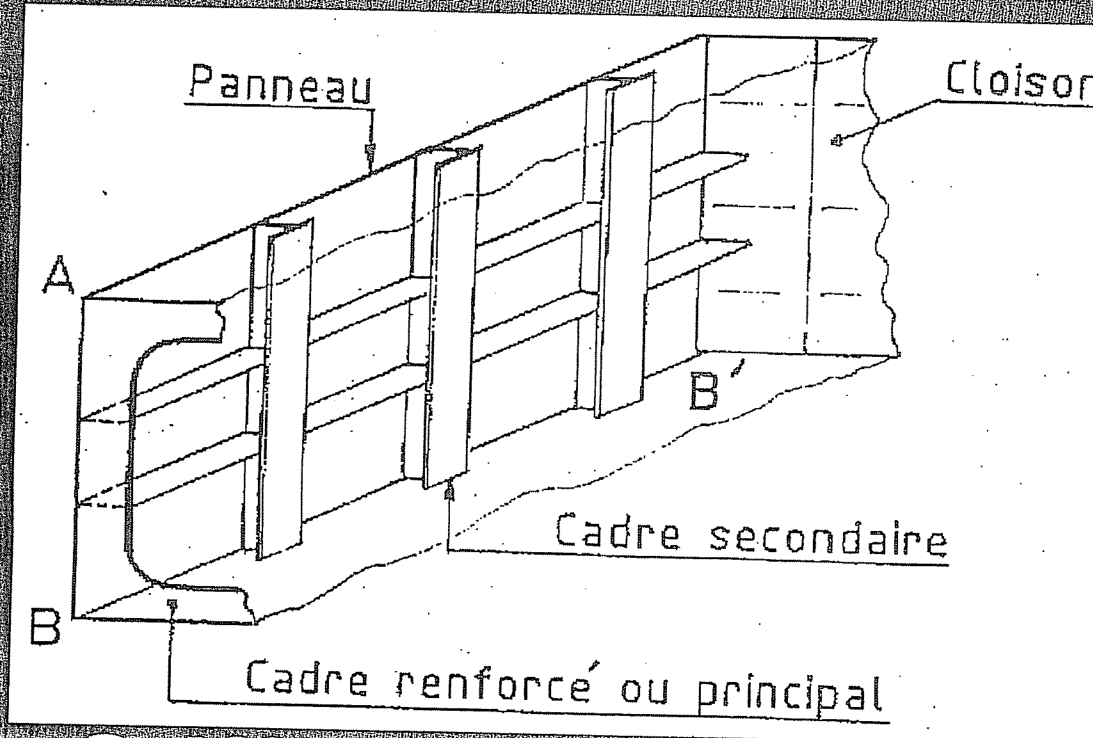
RATIONAL STRUCTURAL CONSTRAINTS

Primary & Secondary Stresses + local stresses

Longitudinal & Transversal Bending

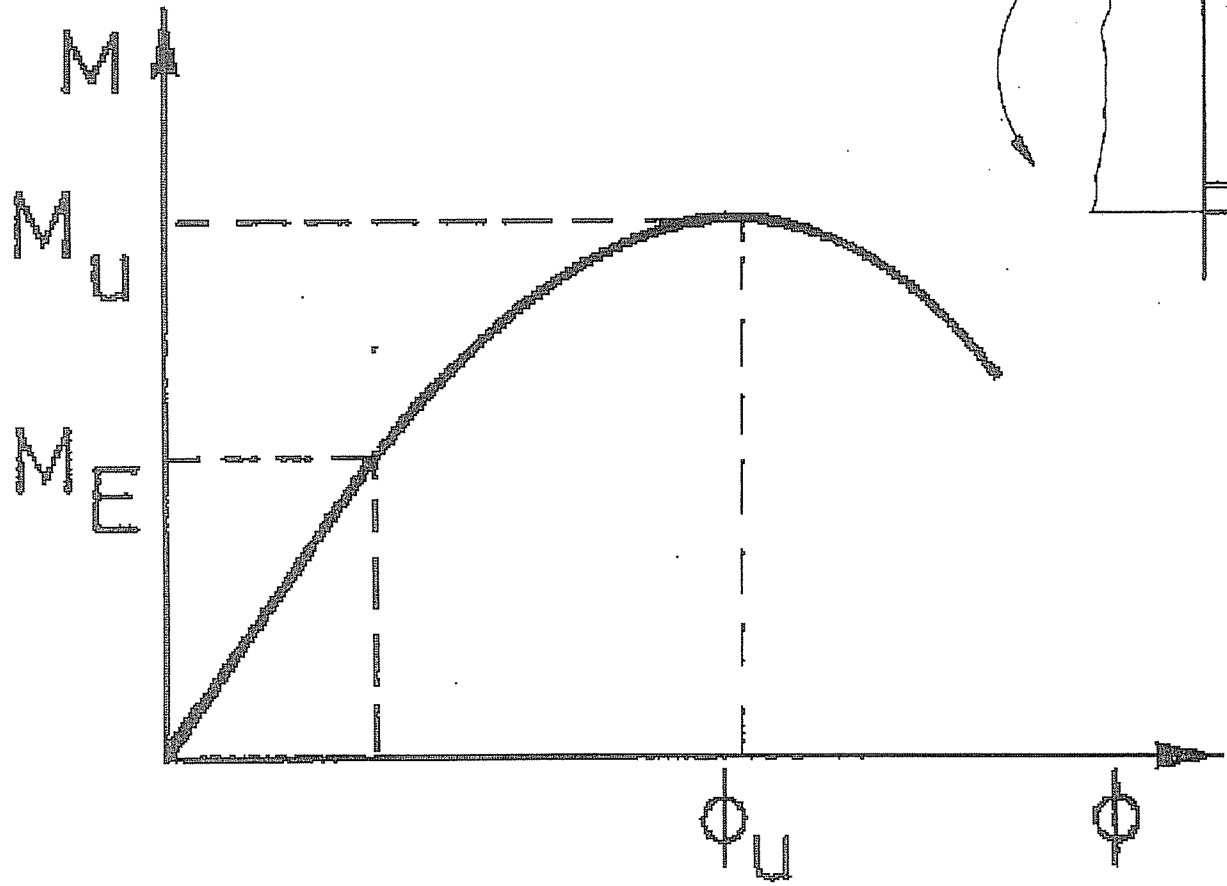


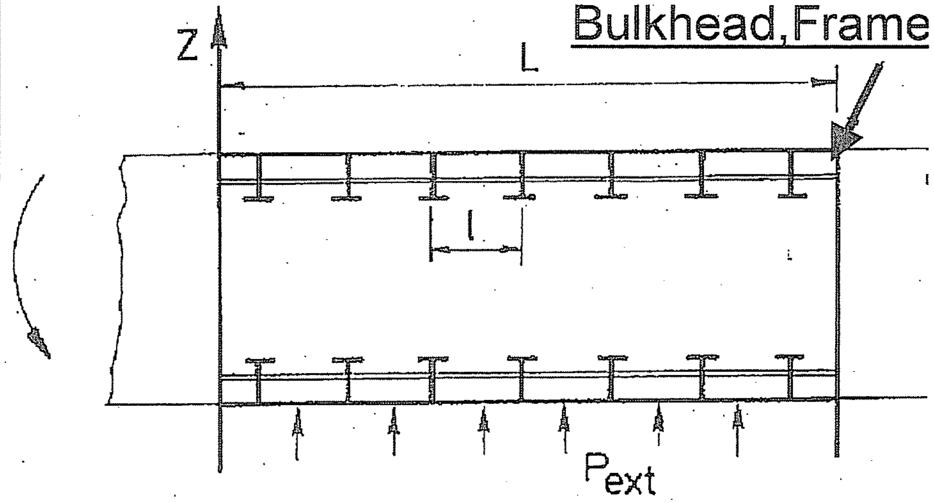
STRUCTURAL CONSTRAINTS
- Instability of the Stiffened Panels -



- Global
- Inter Frame Stiffened Panels
- Stiffeners, frames : tripping, ..

ULTIMATE BENDING MOMENT of HULL GIRDER = Constraint





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2. The COST MODEL

Material (Steel, welding mat., ...)

$$P_{MAT} = \sum_{j=1}^{K} Q_j \cdot P_j$$

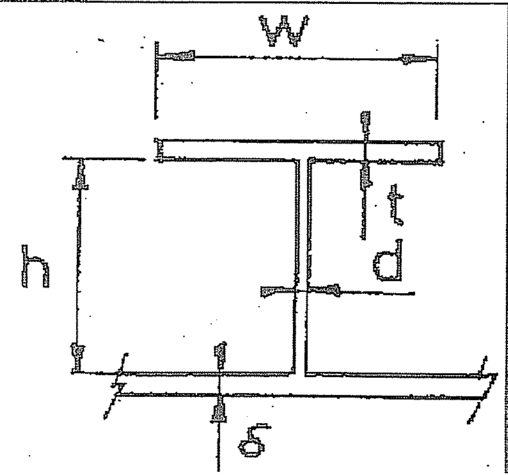
Labour Costs

$$P_{Labor} = \sum_{i=1}^{NT} \cdot T_i \cdot M_i \cdot S_i$$

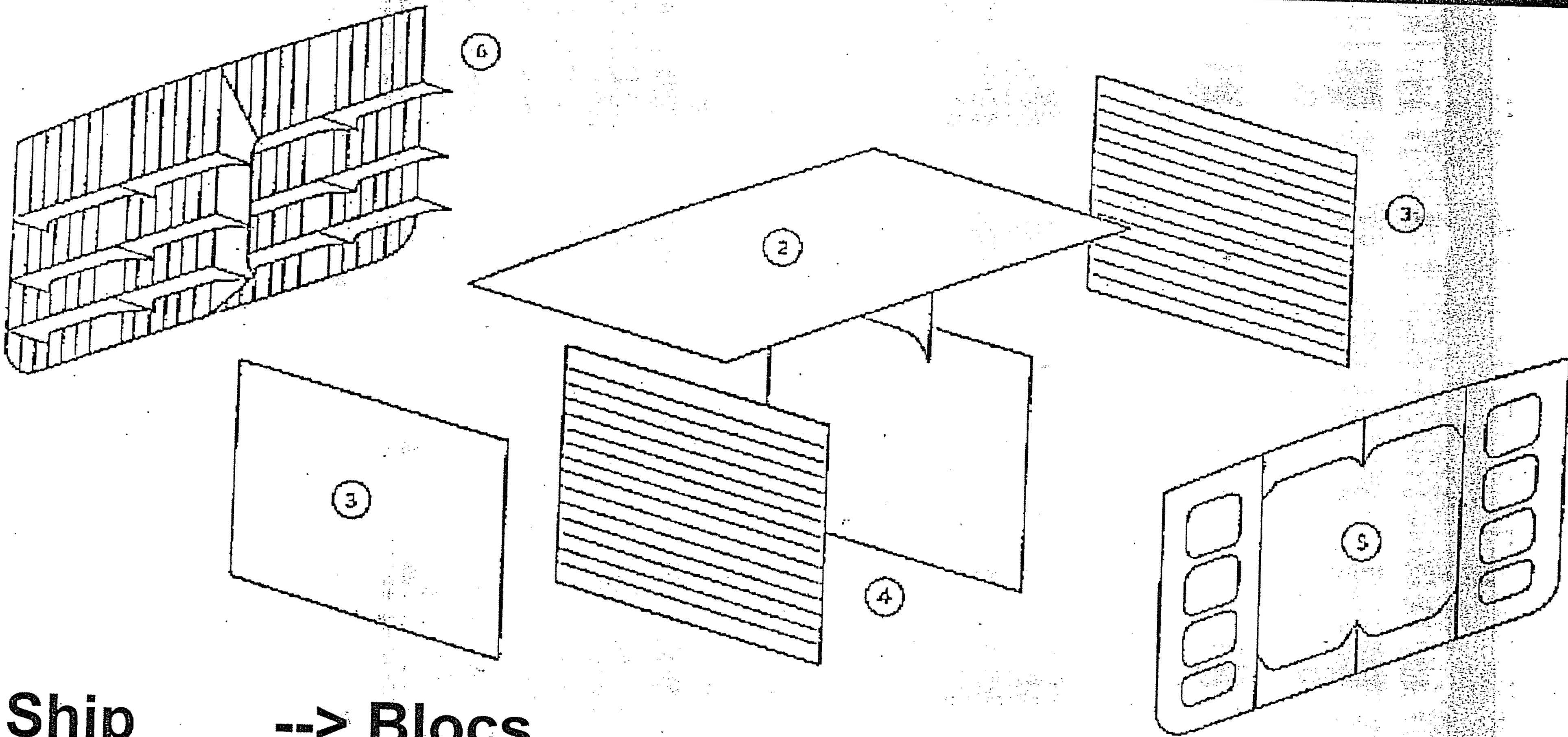
Overhead Costs

- Material Costs -

$$F_{MAT} = \gamma \; L \; B \left[\begin{array}{l} C_1 . \delta \\ + C_2 . \dfrac{(h.d + w.t)_X}{\Delta_X} \\ + C_3 . \dfrac{(h.d + w.t)_Y}{\Delta_Y} \end{array} \right] \quad (Euro)$$



BREAKDOWN OF THE CONSTRUCTION



Ship --> Blocs
Blocs --> Modules
Modules --> Panels and Sub-Panels
Panels --> Elements (plate, stiffener)

LABOUR COSTS

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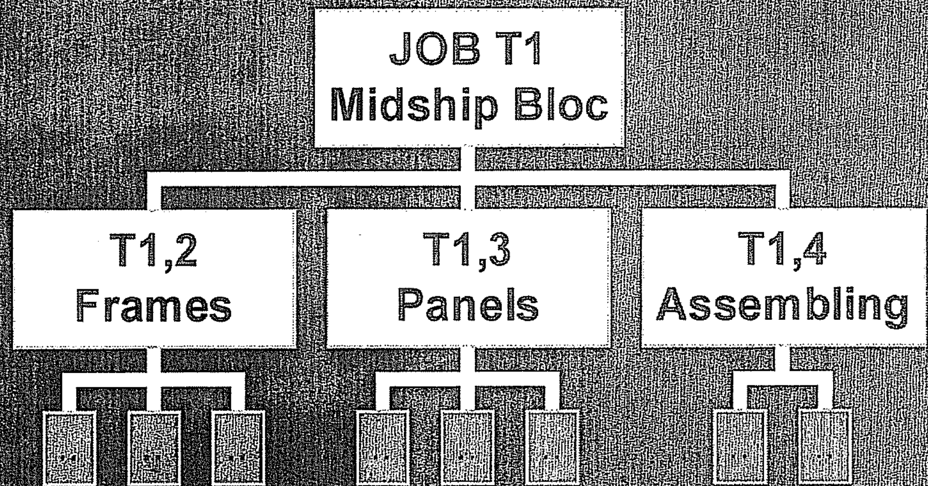


$$P_{Lab} = \sum_{i=1}^{NT} . T_i . M_i . S_i$$

NT = Number of different types of standard jobs (i=1,NT),

T_i = Labour load of a standard job (i) ; (man-hours),

M_i = Number of time the job (i) must be repeated ,

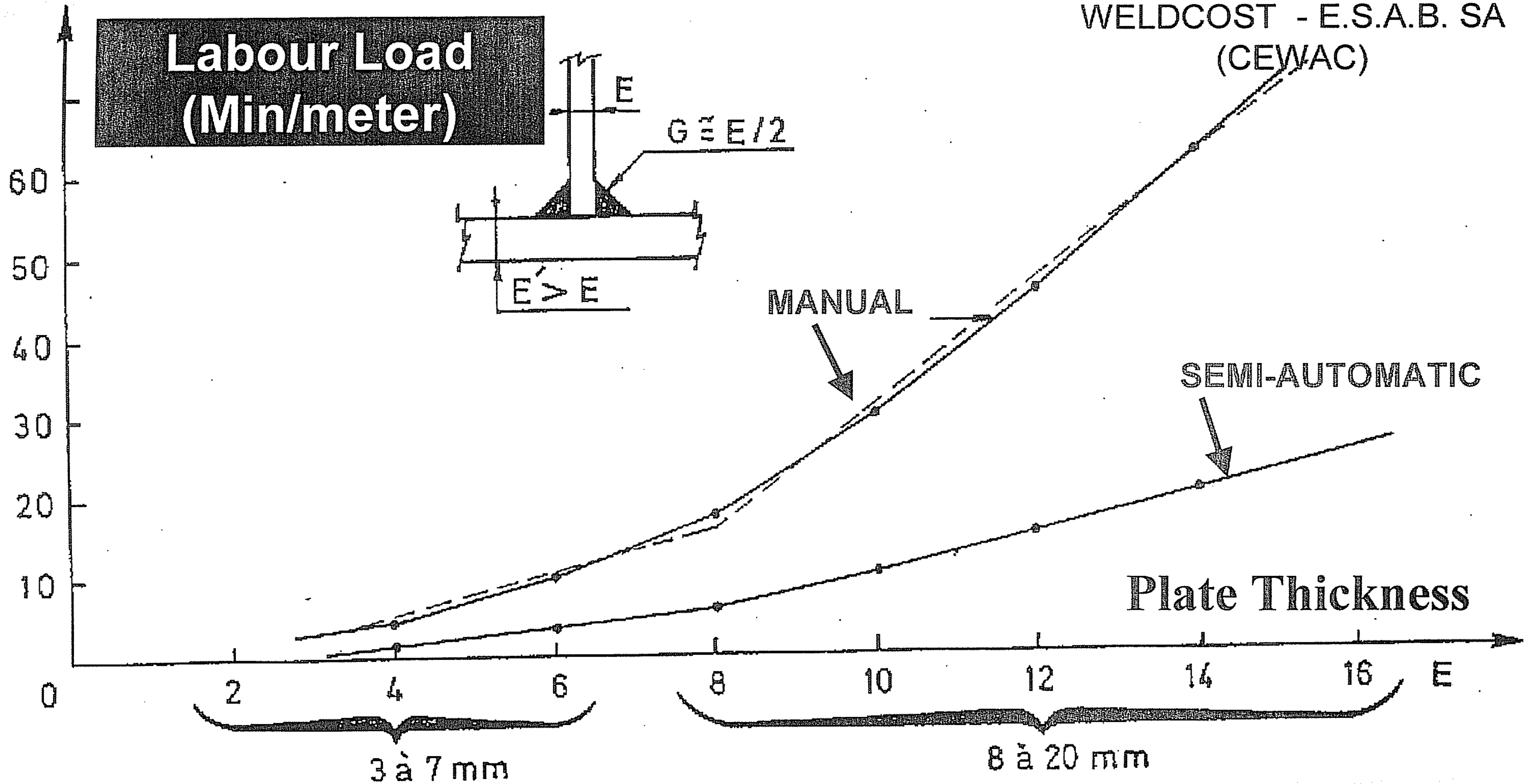
S_i = Unitary labour cost of a standard job (i) ; (FB/h-h)

- LABOUR COSTS -

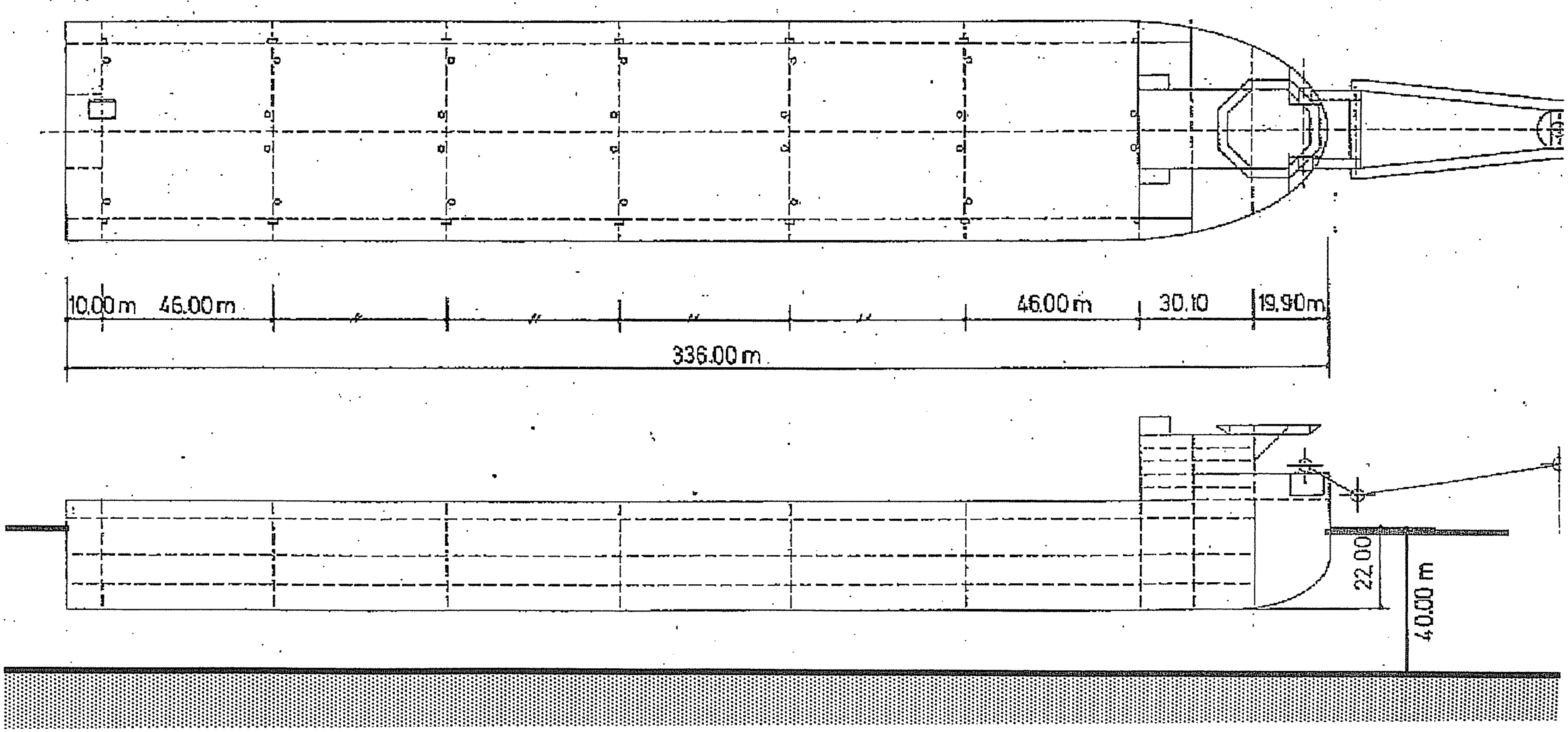
$$F_{Labour} = \eta \, . \, k \, . \, C_1^o \, . \, LAB$$

$$LAB = L \, . \, B \left[\begin{array}{l} \frac{1}{\Delta_X} . P_4 + \frac{1}{\Delta_Y} . P_5 \\ + \frac{1}{\Delta_X . \Delta_Y} \left(P_6 + \beta_X . \beta_Y . P_7 \right) \\ + \frac{1-\alpha_X}{\Delta_X} . P_9(X) + \frac{1-\alpha_Y}{\Delta_Y} . P_9(Y) \\ + P_{10} \end{array} \right]$$

- Labour Cost - WELDING -



Floating Storage Offloading (FSO)



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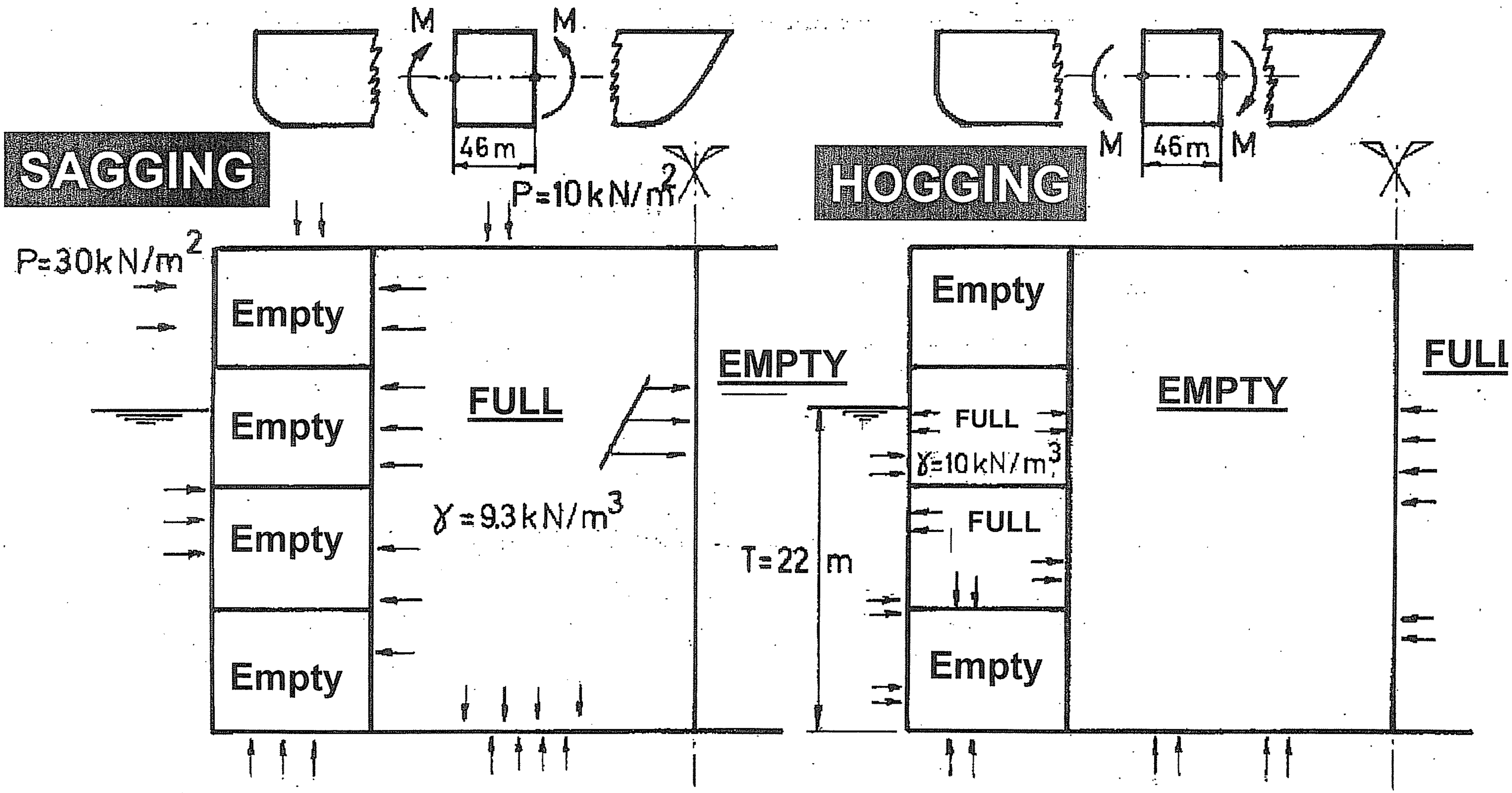

LOADING CASES

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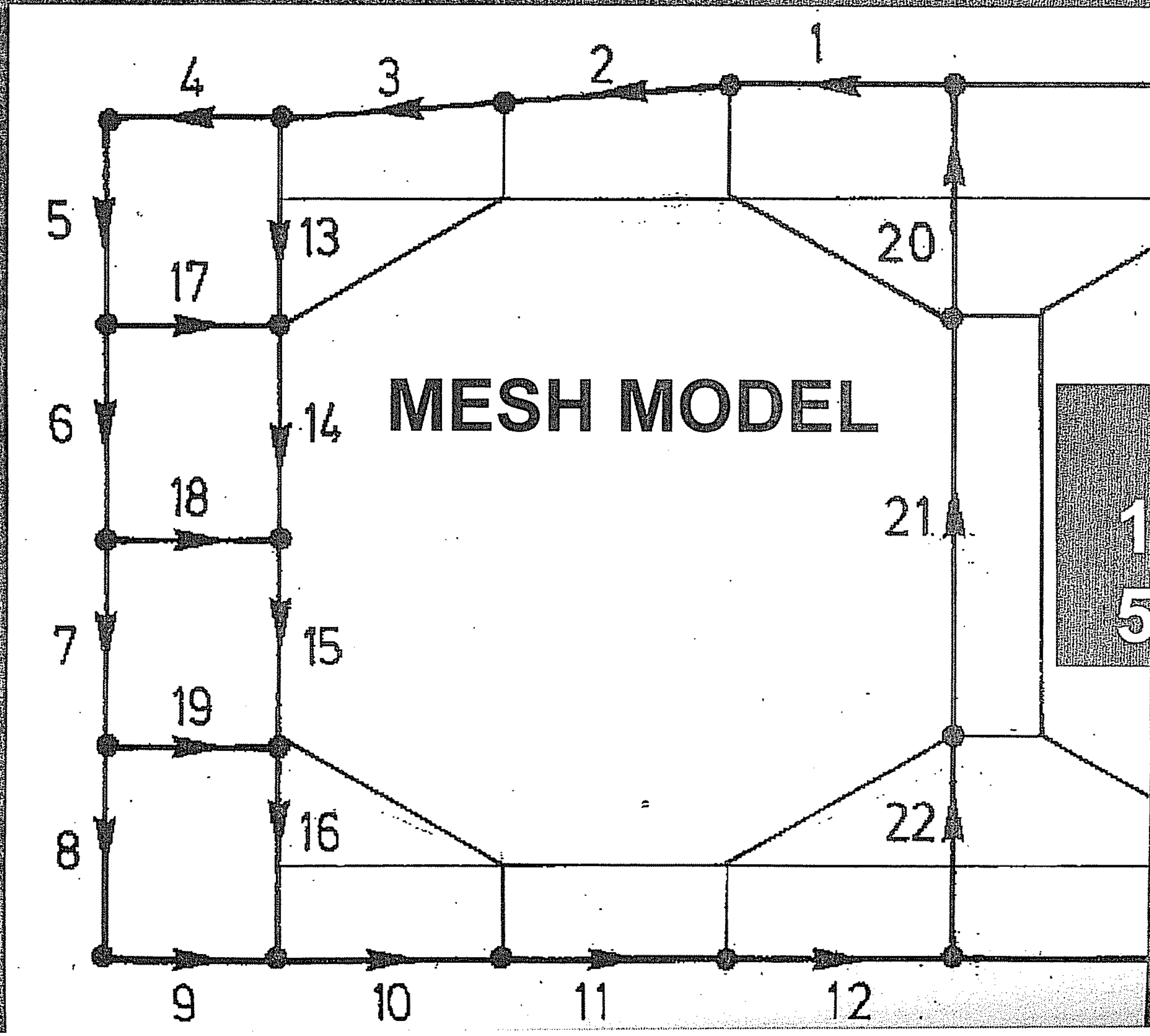
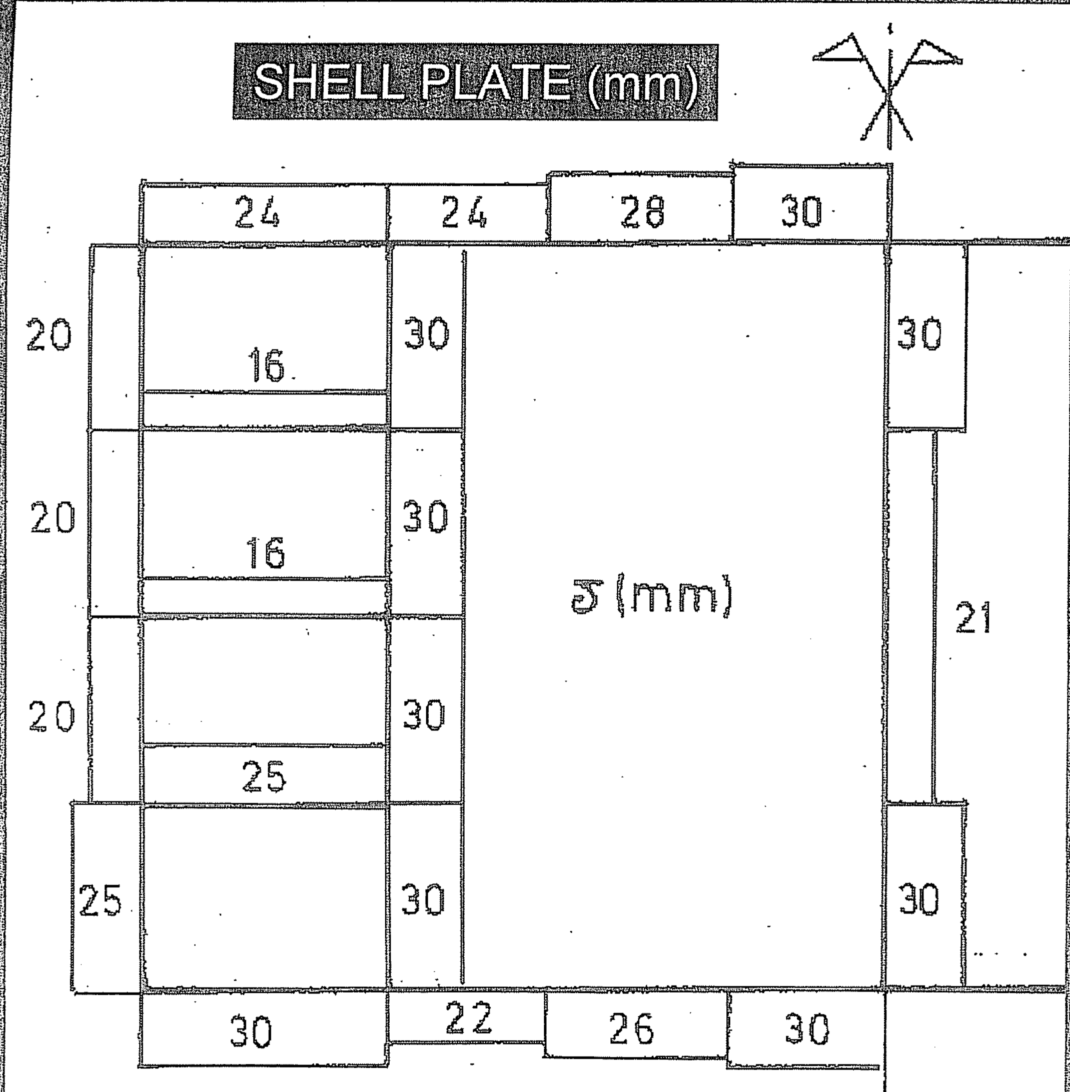
Floating Storage Offloading (FSO)



22 Panels
198 Variables XI
594 Constraints

Floating Storage Offloading (FSO)



Optimum

Plate Thickness

with

$\delta \leq 30$ mm

Floating Storage Offloading (FSO)

Configurations	Weight (%)	Cost (%)	Cost (FB/kg)
Minimum Weight			
$\delta < 30$ mm	143%	152%	100,9
$\delta < 40$ mm	100%	106%	97,7
Minimum Cost			
$\delta < 30$ mm	145%	134%	88,5
$\delta < 40$ mm	109%	100%	87,4
INITIAL SCANTLING	147%	154%	99,8

L.B.R.-5 : Goals

1. Structural Optimisation
   - Optimum Scantling (or Design)
2. Cost Objective Function
3. Tool for Preliminary Design
4. Polyvalence
   - Naval & Hydraulic Structures

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