

INTELLIGENT OPTIMAL DESIGN OF A BEAM DURING THE CRASH

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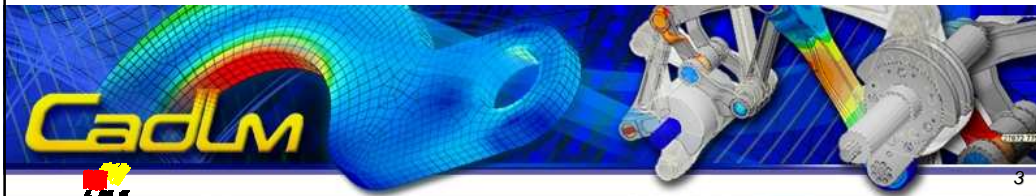
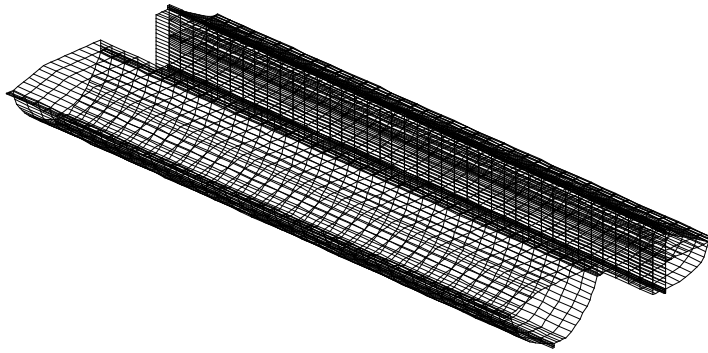


APPLICATION IN OPTIMAL DESIGN OF A BEAM

- ▮ *Used in cars*
- ▮ *During a crash :*
 - *the maximal load must be limited !*
 - *the dissipated energy for a given displacement must reach a maximum value !!*
 - *Germany : dedicated center > 15 000 tests*
 - *USA : > 8 000 numerical simulations*



APPLICATION IN OPTIMAL DESIGN OF A BEAM



- ┌ *Dedicated system*
 - *for any cross section*
 - *for any type of assembly*
- ┌ *to give the minimum load and the maximum dissipated energy*
- ┌ *the optimal design for any new requirements*



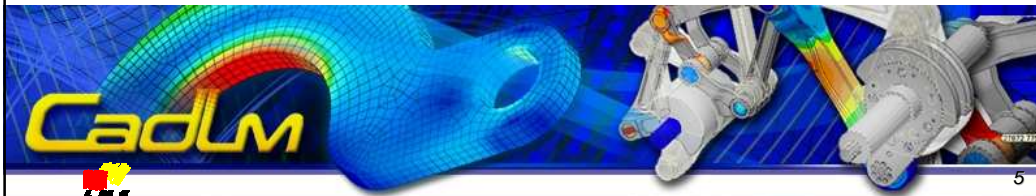
APPLICATION IN OPTIMAL DESIGN OF A BEAM

└ PRIMITIVE DESCRIPTORS

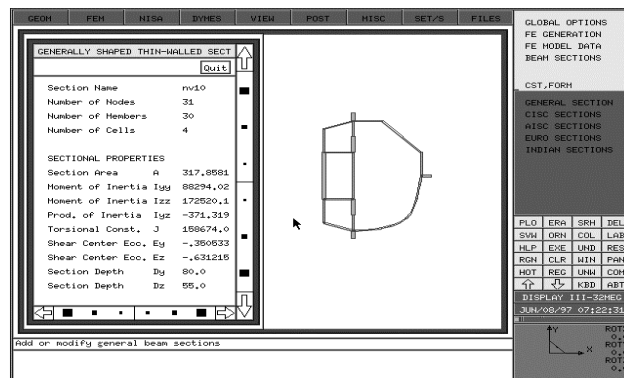
└ INPUT DESCRIPTORS

└ 1. GEOMETRY OF NORMAL SECTION (NISA from EMRC):

- Numbering each NODE
- Definition of and numbering each MEMBER (connectivity and thickness)
- Definition of and numbering each external or internal CELL



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APPLICATION IN OPTIMAL DESIGN OF A BEAM

add or modify general beam sections

PL0	ERA	SRH	DEL
SVH	ORN	COL	LAB
HLP	EXE	UNDI	RES
RGN	CLR	WIN	PAN
HOT	REC	LINK	COH
↑	↓	KBD	ABT

DISPLAY III-32HEG
JUN/08/97 07:34:47

ROT1 0.0
ROT2 0.0
ROT3 0.0

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- ┆ 2. MATERIALS
- ┆ 3. ASSEMBLY OF THE PARTS:
 - Type : weld, glue, bolt, ...
- ┆ weld
 - continuous or by step
 - number of spots

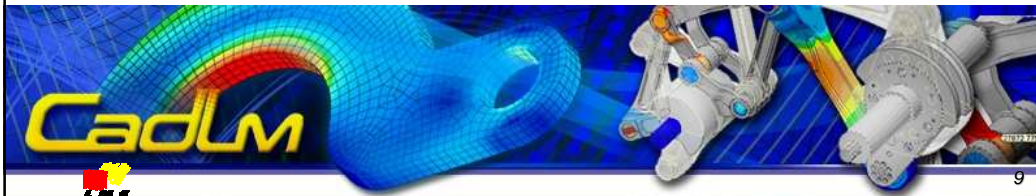
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APPLICATION IN OPTIMAL DESIGN OF A BEAM

▮ OUTPUT DESCRIPTORS

⇒ 4. CONCLUSIONS

- Maximal Load
- Dissipated energy



APPLICATION IN OPTIMAL DESIGN OF A BEAM

dynamical CRASH simulation with RADIOSS.

- *loading : one end clamped and on the other one rigid mass of 100 kg is sent at the initial speed of 10m/s.*
- *resulting axial force and the dissipated energy in function of the time.a displacement of 15 mm.*
- *On a Silicon graphics workstation (Indy R 4400) 1 to 2 hours !!!*

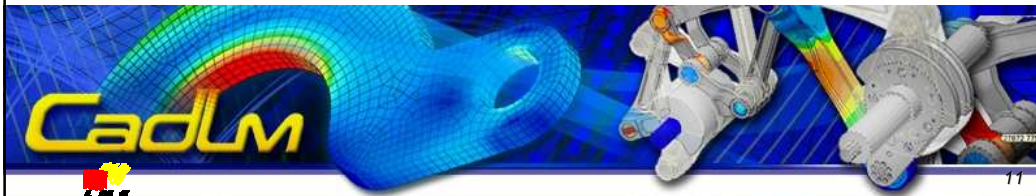


APPLICATION IN OPTIMAL DESIGN OF A BEAM

└ INTELLIGENT DESCRIPTORS

└ 1. GEOMETRY OF NORMAL SECTION

- Area
- Moments of inertia about centroid
- Product of inertia
- Torsional constant
- Coordinates of centroid
- Principal axes orientation



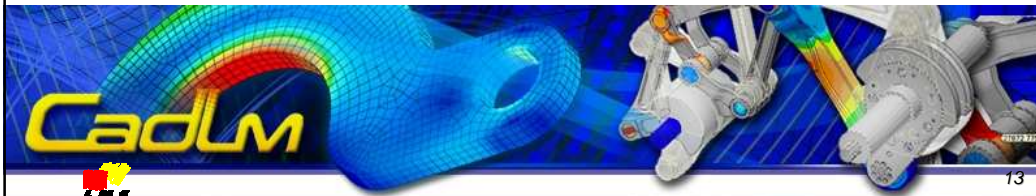
APPLICATION IN OPTIMAL DESIGN OF A BEAM

- ⇒ Eccentricities of shear center
- ⇒ Depths of section
- ⇒ Sections modulus
- ⇒ Warping constant ...
- └ 2. MATERIALS
 - Elastic constants
 - Plastic constants
- ☐ Nothing is taken when same used materials !!!



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- 3. ASSEMBLY by welding : most critical and difficult part !
 - each spot weld ==> small beam
 - Total number of small beams with special properties
- **Global Moment Elastic Torsion** or properties during one elastic dynamic step loading



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- *Generating the rules*
- $$\begin{aligned} \text{NRJ-INT} = & -1.85e-02 * \text{IZZ} + 2.04e+03 * \text{DZ} + 4.842e-02 * \\ & \text{MOMENT-TORSION} -6.9e-01 * \text{J} + -1.07e-04 * \text{SURF} * \text{IYY} -1.98e-04 * \\ & \text{SURF} * \text{MOMENT-TORSION} + 1.24e-03 * \text{SURF} * \text{IZZ} -3.34e-04 * \text{J} + \\ & 9.84e-07 * \text{IZZ} * \text{J} -1.25e-03 * \text{J} + -1.79e-04 * \text{DZ} * \text{MOMENT-TORSION} \\ & + -7.5e-13 * \text{IZZ} **2 * \text{J} + 9.00e-07 * \text{IZZ} **2 + 5.57e-06 * \text{IZZ} **2 + \\ & 8.76e-03 * \text{DZ} **2 + -4.08e-10 * \text{SURF} * \text{IZZ} **2 + 1.955e-19 * \text{IZZ} \\ & **2 * \text{J} **2 \end{aligned}$$
- *Similar expression for EFF-MAX*



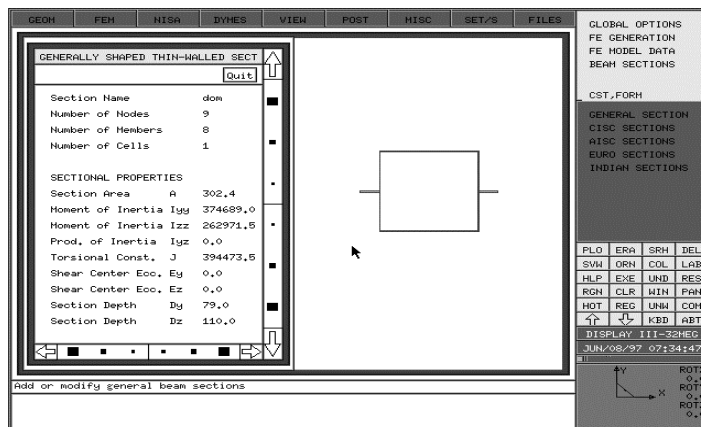
OPTIMAL DESIGN

- ┌ Requirements
 - Maximun load < 150 000 N
 - geometrical constraints
- ┌ find the solution to get the maximal value of the dissipated energy
 - in the space of the intelligent descriptors
 - solution NRJ-INT = 6 672 127 with EFF-MAX = 11 200
 - great improvement !!!!
 - Meaning of the solution ?
 - Does it exit ?
 - How to obtain it ?



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APPLICATION IN OPTIMAL DESIGN OF A BEAM

APPRENTISSAGE						
SURF	6.21E+02		J	924594.73		
6.21E+02				-5.22E+06		
IZZ	786350.24			6.14E+06		
-3.45E+06				7.84E+02		
4.24E+06			DZ	9.28E+01		
1.41E+02				9.28E+01		
IYY	736712.76		DY	1.14E+02		
-5.54E+05				1.14E+02		
1.91E+06						
-6.17E+05						
EFF-MAX	154990.53		NRJ-INT	2.13E+06		
7.22E+05				-1.87E+06		
-6.73E+05				4.51E+06		
1.05E+05				-5.10E+05		
PARAMETRES DE CONCEPTION PRIMITIFS						
LW	LS	H	EP	STEP	NB-BEAM	
17.558794	39.5003548	46.4053307	1.5	17	49	
PARAMETRES EVOLUES INTEELIGENTS						
SURF	IZZ	IYY	J	DZ	DY	
6.21E+02	786350.24	736712.76	924594.73	9.28E+01	1.14E+02	



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Optimal solution 2

NRJ-INT = 2 100 000

EFF-MAX = 154 999

for

LW = 18.38 mm LS = 39.5 mm H=47.8 mm

EP = 1.499 mm STEP = 10

NB-BEAM = 82



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	A	B	C	D	E	F	G	H	I
6		1.41E+02							
7	NY		736712.76						
8		-5.54E+05							
9		1.91E+06							
10		-6.17E+05							
11	J		924594.73						
12		-5.22E+06							
13		6.14E+06							
14		7.84E+02							
15	DZ		9.28E+01						
16		9.28E+01							
17	DY		1.14E+02						
18		1.14E+02							
19	EFF		154990.53						
20		7.22E+05							
21		-6.73E+05							
22		1.05E+05							
23	NRJ		2298748.43	INT		2.13E+06		1.07E990133	0.92E934385
24		6.93E+06			-1.87E+06				
25		4.27E+06			4.51E+06				
26		-8.90E+06			-5.10E+05				
27									
28	U31	U32	HAUTEUR	EP	PAS	NBFOUTRE			
29	17.55879+02	39.50035477	46.40533066		1.5	17		49	
30	SURF	I22	NY	J	DZ	DY			
31		6.21E+02	786350.24	736712.76	924594.73	9.28E+01		1.14E+02	
32									
33									
34	V	VRAP2							



APPLICATION IN OPTIMAL DESIGN OF A BEAM

- ┌ RADIOSS
 - ==>NRJ-INT = 1 953 500 J
 - and EFF-MAX = 155 540 N
- ┌ Improved technological solution
- ┌ The design office :
 - able to answer at once to any new requirements
 - with at each time one optimal solution !!



CONCLUSIONS

- ▮ *ACTUAL APPROACH ==>
DESIGN OF THE FUTURE !!!*
- ▮ *ABSOLUTE NECESSITY also in
Control of Processes
Survey of Structures...*
- ▮ *Linking automatic learning
and optimization techniques
with mechanical expertise*

