Project B: Sandwich Helicopter Floor

NH90 Rescue helicopter build in CFRP and NOMEX honeycomb

1. Introduction:

You are working for a helicopter manufacturer and your boss has given you the assignment to perform a preliminary study and design of the floor to a new transport helicopter. The floor shall be designed and manufactured in a composite or aluminium sandwich construction.

In this initial stage of design, no materials or thickness dimensions are given, except for a few geometrical constraints given by the overall preliminary design.

You have only been given 1-2 days to do this job, which should include mechanical calculations, material selections, a suggested manufacturing method, costs and engineering estimates of impact resistance, fatigue, environmental resistance etc. The given time should also include the compilation of a short report.

2. Problem Definition

Perform design, material selection and suggest a suitable manufacturing method for the floor according to the specification given below. Furthermore, the following items should be considered:

- The criteria for the design are: low weight – long life – low cost, given in order of importance
- Consider aspects such as material costs, manufacturing method, wear, fire and other important issues for the design. Can any of these provide critical design constraints?
- Compare your solution with other plausible designs, such as stiffened single skin composite or metal skins
- Verify that your analysis tool is actually giving you reliable results. This can be done against either a numerical or analytical alternative method.

Specification

Geometry (see Figures 1 , 2 and 3)
The sub-structure of the helicopter carries all global loads and consists of a stiffened shell. The floor is divided into three main panels, see Figure 3, which is joined to the rest on the substructure.
The total floor thickness may not exceed 30 mm due to compartment volume restriction.

Load cases
The design load cases are:

- A load of 800 kg/m^2 evenly distributed over the entire floor
- A downwards acceleration of 4.5g
- Fuel tank pressure of 3.00 kPa, acting upwards on the floor when the tanks are full
- A local load of 100 N acting on an area of 100 mm^2

Safety factors
A safety factor of 1.5 should be used against material failure. For metallic sheet materials, the yield point may be used as the allowable load case, but for composite materials, which generally not yield prior to failure, an additional factor of 1.2 should be used.

Stiffness
There is no set of stiffness requirements formulated for this application. However, people walking on the floor dislike to walk on a floor, which deflects too much. “It makes you feel that it will not hold”.

Assembly
The floor panels are to be manufactured separately and then joined to the sub-structure.

Material data and costs

Material data can be taken from course material, handbooks, internet or other sources.

Some material prices (estimates from 1995 – you are welcome to find newer data)

	$/kg
Aluminium plating	3
Stainless steel plating	3
E-glass mat (CSM)	2.5
E-glass woven roving (WR)	3
E-glass weave	8
E-glass unidirectional (UD)	5
Kevlar weave	50
Kevlar uni-directional (UD)	35
Carbon fibre weave	75
E-glass/epoxy prepreg	45
Kevlar/epoxy prepreg	70
Carbon/epoxy prepreg	100

	$/kg
Epoxy	5
Polyester	2
Vinylester	3
Nomex honeycomb < 50 kg/m^3	80
Nomex honeycomb > 50 kg/m^3	60
Aluminium honeycomb < 50 kg/m^3	150
Aluminium honeycomb > 50 kg/m^3	130
PMI foam core	30
PVC foam core	13
PS foam core	8
PUR foam core	2

Reporting

The assessment of the design task is based on a short report. This should include all important results obtained, specifically:

- Specification of the problem
- Used design constraints and other important decisions
- Design formulas used
- Calculations (in appendix)
- Evolution of the design
- Conclusions and suggestions for future work

The format of the report

No more than 25 pages of text (12 pt with single line spacing) including illustrations and tables but excluding abstract, various lists of content and list of references will be accepted. Furthermore, content of possible appendixes will not be counted as basis for the acceptance of the report.

Your report should as a minimum include the following sections:

- Abstract
- Introduction

- Problem formulation. Note that you should not necessarily just copy the problem definition from the assignment. If you think you can improve the problem description, feel free to do so.
- Method of analysis
- Results and discussions
  In deciding on the figures to show in your report you should be rather s elective. Remember a good report is not a question on how many figures there is in the report but on how well they contribute to the understanding of the solving of the problem, the results obtained and the final conclusions, and on how well these figures are discussed.
- Conclusions

3. Lessons learned

During the course of this task, you should have learned something about:

- How to design with composite and sandwich constructions
- How to practically perform an integrated design/material selection process
- Get insight into the fact of performance costs
- That a mechanically feasible and sound design is not always practical
- Get some practice of how to use the theoretical knowledge recent obtained
- That in reality there are no correct answers – only good and bad ones!

4. Figures

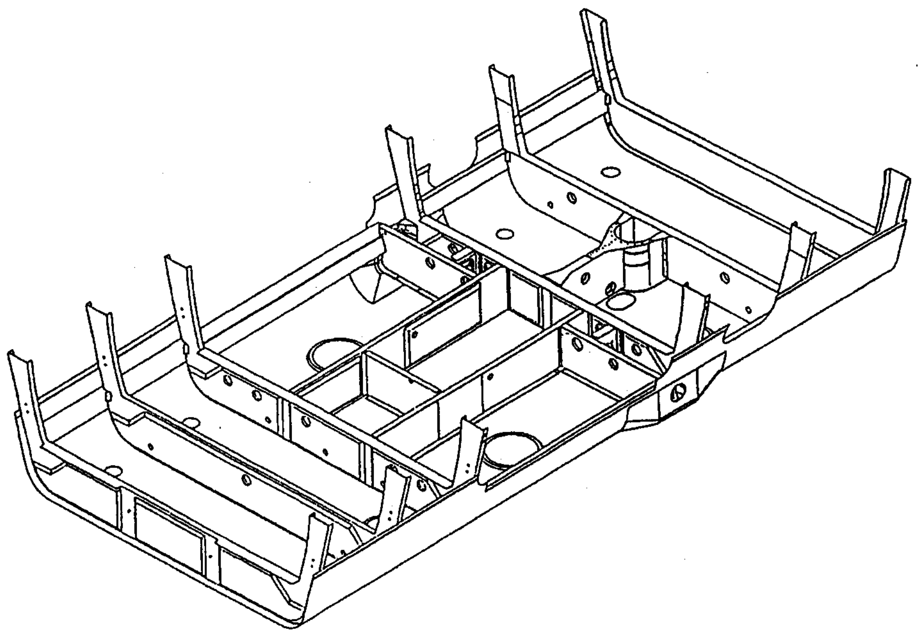

Figure 1. Schematic view of sub-structure.

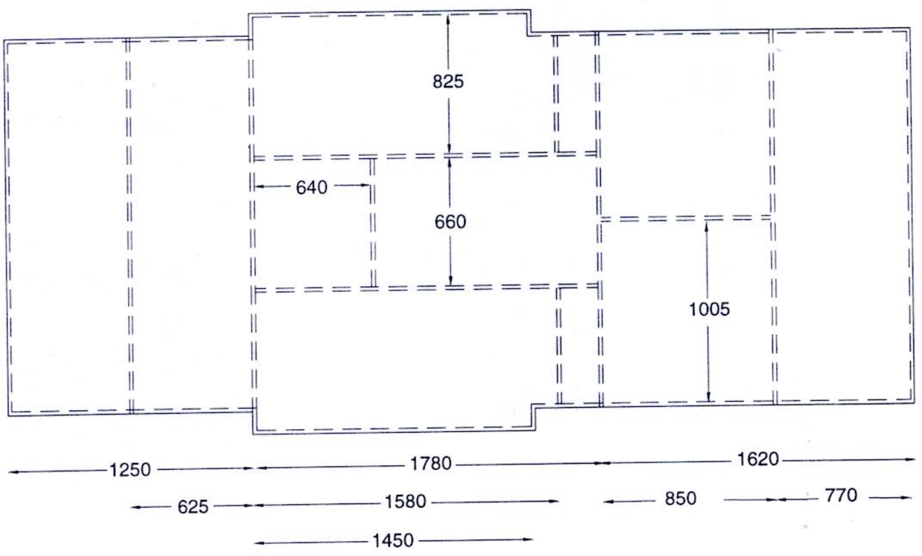

Figure 2. Dimensions of sub-structure in millimeters between centerlines of the webs. Each web has a width of 50 mm.

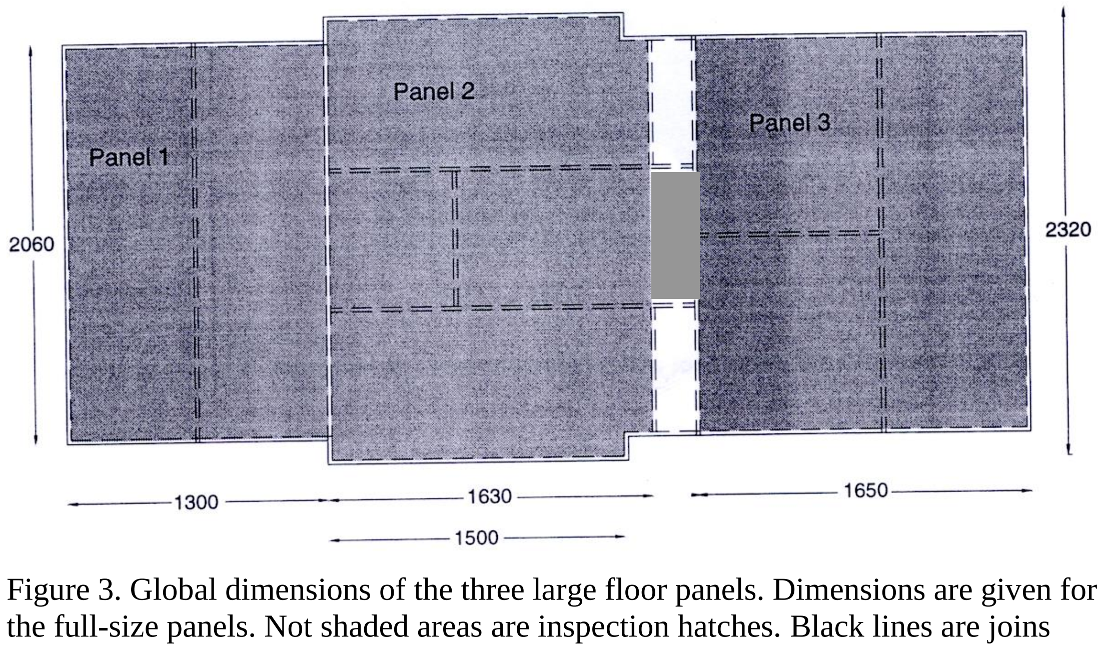

Figure 3. Global dimensions of the three large floor panels. Dimensions are given for the full-size panels. Not shaded areas are inspection hatches. Black lines are joins between sub-panels.