CoA Memo. No. 203

September, 1969

THE COLLEGE OF AERONAUTICS

DEPARTMENT OF AIRCRAFT DESIGN

Application of Inflated Structures to Hovercraft

Annual Survey 1968-69

Inflated Structures Report C1206/3

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17th September, 1969

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1.0 Introduction

This report surveys work carried out in the Department of Aircraft Design at the College of Aeronautics, Cranfield, in accordance with the terms of Ministry of Technology contract reference PD/28/045/ADM, College of Aeronautics reference C.1206. The period covered by this report extends from 1st October 1968 to 1st October 1969, which constitutes the first complete year of operation under the contract terms.

The reporting procedure agreed with Mintech is that individual research topics shall be separately reported in the form of technical memoranda, and that comprehensive surveys of a descriptive nature shall be submitted at regular intervals.

2.0 Scope of research

The original terms of reference for research were quite wide. All aspects of inflated structure engineering were to be reviewed initially, and it was anticipated that certain well defined lines of research would emerge.

Activities have been concentrated in three important areas:

(i) analysis of existing work

(ii) configuration studies

(iii) evaluation of material properties.

3.0 Research activities

3.1 Bibliography

Throughout the period covered by this report, published information has been continuously acquired and evaluated. Following discussions at Cranfield (item 3.6.2.) and with the A.R.C. Engineering Physics sub committee (item 3.6.5.) the decision was taken to prepare a formal bibliography for reference purposes.

A format has been chosen which allows easy chronological and subject reference, and permits continuous updating.

A draft version of the bibliography is now complete, and awaits a decision on method of reproduction and circulation.

3.2 Multicellular struts

The effects of the compression of multicellular inflated struts between various rigid boundary profiles have been studied. Relationships between applied load, deformation, and wall stresses have been derived on the assumption that cell walls are flexible but inextensible. On this basis the influence of cell configuration on energy absorbtion potential has been estimated. This work has been extended to include consideration of Euler type instabilities under compressive loading.

A valuable link with R.A.E. Cardington has been established which has led to cooperation in the exchange of information, and the manufacture and testing of inflated structures. Cardington have recently produced three large two-cell inflated beams which are currently being tested in the College laboratories, in support of the studies mentioned above.

The results of this work are expected to have application in the design of inflated members as protective structures.

3.3 Lifting bag tests

A short series of tests have been performed in the College laboratories to evaluate the performance of cylindrical inflated lifting bags. These tests, which were conducted in cooperation with R.A.E Cardington and the Bedfordshire County Fire Service, have provided the opportunity for the development of experimental techniques for inflated structures.

Use was made of the 150 ton Denison compression testing machine, which offers unique advantages for the testing of this type of structure, with platens 60 in. x 36 in. and maximum daylight of 180 in. These tests were reported in a brief factual note to the authorities concerned.

3.4 Optimum multi-cell beam

A brief study of the stiffness properties of matress-type multicellular beams has produced solutions for optimum cell spacing to give maximum shear and initial bending stiffness. Optimum spacing and stiffness was derived as a function of rib wall thickness. This work is reported in Inflated Structures Report C1206/2, now complete.

3.5 Biaxial strain measurement

A thorough understanding of material behaviour is an essential foundation for any rational structural design procedure. Stress-strain data is particularly important, and this information is not generally available for the coated woven fabrics used in inflated structures, particularly under biaxial loading conditions. The measurement of strain distribution in complete structures is a valuable aid to the prediction of

failures, and the improvement of existing designs. Such measurements are difficult to achieve with reasonable accuracy, since strains are often large (up to 50%), and the surfaces involved usually have compound curvature.

Previously methods of strain measurement have involved either measurement of pre-marked grids on the loaded surface, or direct readings from adhesive uniaxial strain gauges, which could themselves affect the strain distribution.

A method has been proposed which overcomes these difficulties, giving accurate biaxial strain measurements without interference with the loaded surface, with a minimum of investment in measuring equipment.

The method is outlined in Inflated Structures Report C1206/1 which is now complete.

3.6 Liaison programme

Visits have been made to a number of establishments connected with inflated structures research and development.

3.6.1 British Hovercraft Corporation, I.O.W. Feb. 24th, 1969

Discussions regarding hovercraft development and the role of inflated structures.

Full report of visit on file.

3.6.2 College of Aeronautics, Cranfield. Feb. 25th, 1969

Meeting promoted by Mintech to discuss inflated structures developments. Industrial and research establishments widely represented.

Meetings fully minuted, circulated through Mintech.

3.6.3 Marston Excelsior Ltd., Wolverhampton. March 19th, 1969

Discussions on proofed fabric manufacture and quality control, and demonstration of flexible structure fabrication.

Full report of visit on file.

3.6.4 F.P.T. Ltd., Portsmouth. March 20th, 1969

Discussions re. inflated structure design procedures, demonstration of manufacturing methods including jointing of fabrics.

Full report of visit on file.

3.6.5 A.R.C. Engineering Physics Sub-Committee, Cardington. May 16th, 1969

Attendance at sub-committee discussion of Inflated Structure applications and research.

Reported in A.R.C. minutes.

3.6.6 M.E.X.E., Christchurch. June 26th, 1969

Open day demonstration of inflated airbridge, floating bridge, fascine, vehicle lifting bags.

4.0 Continuation proposals

It is proposed that inflated structure research shall continue at Cranfield, with concentration on the following areas:

4.1 Multi-cell configuration studies, including stability.

4.2 Development of biaxial strain measurement technique.

4.3 Fabric testing under biaxial loading and development of failure theory.

4.4 Bibliography development, including circulation of draft document for comment and additions.

4.5 Initiation of design study for inflated sidebody for large hovercraft, for which loading is available.