



# INSPIRING THE NEXT GENERATION

**IASS2020/21 - SURREY 7**

▶ **AUGUST 23<sup>rd</sup> - 27<sup>th</sup> 2021** ◀

The 7<sup>th</sup> International Conference on Spatial Structures  
and the Annual Symposium of the IASS

Edited by: Alireza Behnejad, Gerard Parke and Omidali Samavati



**IASS 2020/21  
SURREY 7**

International Conference on  
Spatial Structures 2020/21



**UNIVERSITY OF  
SURREY**

# ▶ SESSION 17

## Tuesday, 24 August

Parallel Sessions,  
**10:30 - 11:45**  
(75 minutes)

Conservation and preservation of 20th century historic concrete shells (IASS WG 5)-1

**Chair(s):** Marisela Mendoza and John Chilton



**660**  
**Morphological analysis of architectural work by F. Candela the form & aperture shape of the HP shell structure**

Masafumi Tanaka\* and Sumika Inoue

Morphological features of F. Candela's architectural works

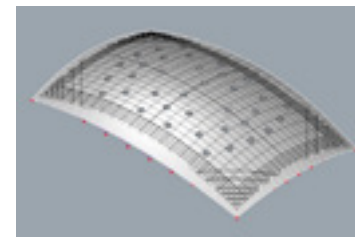
Structural type	Sub-category	Examples		Usage	
		HP shell	HP shell	HP shell	HP shell
Shell structure	Hyperbolic Paraboloid Shell	HP Shell	HP Shell	HP Shell	HP Shell
		HP Shell	HP Shell	HP Shell	HP Shell
Shell structure	Hyperbolic Paraboloid Shell	HP Shell	HP Shell	HP Shell	HP Shell
		HP Shell	HP Shell	HP Shell	HP Shell
Shell structure	Hyperbolic Paraboloid Shell	HP Shell	HP Shell	HP Shell	HP Shell
		HP Shell	HP Shell	HP Shell	HP Shell
Shell structure	Hyperbolic Paraboloid Shell	HP Shell	HP Shell	HP Shell	HP Shell
		HP Shell	HP Shell	HP Shell	HP Shell

Felix Candela is the world's first engineer who has built a structure using the Hyperbolic Paraboloid Shell (hereinafter abbreviated as HP Shell [1]). In particular, he has built many shell structures made of reinforced concrete mainly in Mexico. The feature of the HP shell structure designed by Candela is that it not only uses the HP shell alone, but also creates a work by combining multiple HP shells. In the experiments that started in the 1940s, he completed the basic umbrella-type HP shell system by combining four HP shells, and successfully created many structural forms. In this study, focusing on the morphological features of Candela's architectural works, i.e. the shape of the opening and the HP shell structure, we examined the relationship between them to reveal part of the morphological features in Candela's architectural works.



**669**  
**Smithfield Market - assessment of the poultry market roof**

Christian Tygoer\* and James Kingman



Thin concrete shell structures are prone to failure due to buckling. Determining the buckling load factor is therefore a focus of the design today, as it was in the past, although the methods have changed significantly due to the advances in numerical computation.

This paper presents the analysis work undertaken during the assessment of the concrete shell to the Poultry Market Roof. Material testing carried out prior to the analysis proved to be challenging, since there was a wide spread of results, likely due to the thinness of the shell. Therefore upper and lower bound material parameters have been used during the analysis. The concrete shell was modelled using the analysis software SOFiSTiK considering the construction, loading history and effects of creep and shrinkage. Nonlinear geometric and material analysis studies were carried to study the concrete shells behaviour using upper and lower bound material parameters for concrete strength, pre-stressing levels and modulus of elasticity for concrete, in order to understand the influence of each parameter on the structural behaviour of the roof.



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Organised by:  
**Spatial Structures Research Centre**





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Spatial Structures Research Centre,  
Department of Civil and Environmental Engineering,  
University of Surrey



The Spatial Structures Research Centre (SSRC) of the University of Surrey was founded by Professor Zygmunt Stanislaw Makowski in the Department of Civil and Environmental Engineering in 1963. The core aim of SSRC has been conducting research in the design, analysis and construction of spatial structures. Also, education of spatial structures has been at the centre of its ethos over the past six decades. Many different activities have been organised by the Centre over these almost 60 years, in areas such as research, publication, teaching, organisation of conferences, as well as, consulting work.



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