

Simulation of processes and materials

research lines

The Instituto de Tecnología Cerámica (ITC) is a concerted mixed Institute, established by agreement between the Ceramic Industry Research Association (AICE) and Universitat Jaume I of Castellón, which originated in 1969 in response to the needs of companies from the Spanish ceramic cluster. During its more than 40-year history, ITC has articulated a successful university–business cooperation system that has borne its fruits, witness the significant development of the Spanish ceramic tile manufacturing industry.

ITC is committed to providing solid support for Spanish ceramic companies in the defence and enhancement of their strategic positioning in the current global context, principally through innovation-enabling research and development actions, but also through whatever activities might serve to foster the competitiveness and growth of the sector, always based on sustainability criteria and commitment to societal well-being.

ITC's mission is focused on spearheading technology innovation and design processes in the Spanish ceramic sector, anticipating market and consumer needs regarding the uses and applications of ceramic materials, through professionalised management of a qualified human team committed to excellence in the sector.

The competence attained through ITC's wide-ranging research activity enables ITC today to extend its field of action to other types of processes and materials. Particularly noteworthy have been ITC's actions in the field of energy efficiency and the minimisation of industry's environmental impact, as well as in the functionalisation of ceramic surfaces and the achievement of new technical performance and aesthetic features of products related to the habitat hyper-sector and to other industries, such as the high-tech tool, advanced ceramics, automotive, petrochemical sectors, etc.

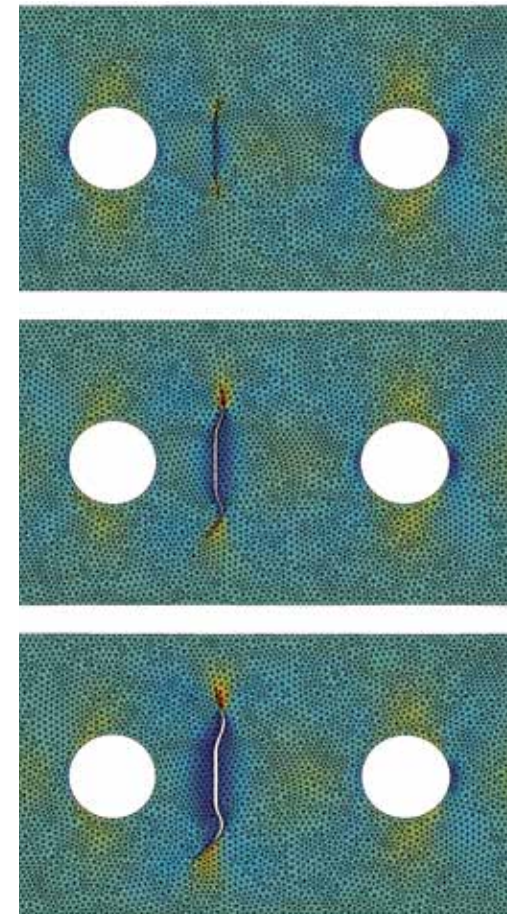
simulation of processes and materials

Simulation is a tool that enables the study of complex systems to be addressed, minimising the performance of laboratory experiments or industrial trials, which are time consuming and expensive.

Simulation allows processes, products, and materials to be optimised by predicting their behaviour under actual service conditions. The methodology is also applicable to the design of new processes and products.

The area of continuous media mechanics and modelling works in different simulation fields, addressing processes (drying, firing, polishing, etc.), product analysis (resistance of items subjected to service stresses, heat transfer in ceramic systems, etc.), and materials analysis (simulation of microstructural damage in glass-ceramic systems).

OVER 1000 R&D PROJECTS DEVELOPED THROUGHOUT THE HISTORY OF ITC, AMOUNTING TO ALMOST 40 MILLION EUROS.



Extended finite element method (XFEM) calculations: crack propagation inside a perforated ceramic piece subjected to tension.

The essential objectives of simulation are as follows:

- › To facilitate the understanding of complex phenomena or processes, enabling variables to be accessed that can hardly be measured experimentally (distribution of tile moisture content in the dryer, tile stresses during firing, tile stresses on impact, heat transfer in complex systems, etc.).
- › To predict the behaviour and evolution of the system being studied when some process variable is modified. Simulation is usually applied when obtaining the relationship between variables involves numerically solving the equations of the model.

Simulation is particularly useful when:

- › It is economically unfeasible to perform experiments under industrial conditions.
- › It is very difficult experimentally to measure magnitudes.
- › It is sought to develop a new product or industrial process.
- › Laboratory data are to be used to predict the performance of a product or process under industrial conditions.

Simulation is a powerful tool that, simply and economically, enables:

- › Existing processes to be optimised.
- › New and more effective processes to be designed, which better match given needs.
- › Materials performances to be enhanced.

IN THE COURSE OF ITS **40-YEAR HISTORY**, ITC HAS CARRIED OUT ABOUT **150,000 ANALYSES AND TESTS** OF THE **475 DIFFERENT TYPES** THAT IT CURRENTLY OFFERS. IN ADDITION, ITC IS A **REFERENCE PARTNER** IN DIFFERENT NATIONAL AND INTERNATIONAL NETWORKS AND TECHNOLOGY PLATFORMS.

Examples of simulations applied to the ceramic industry

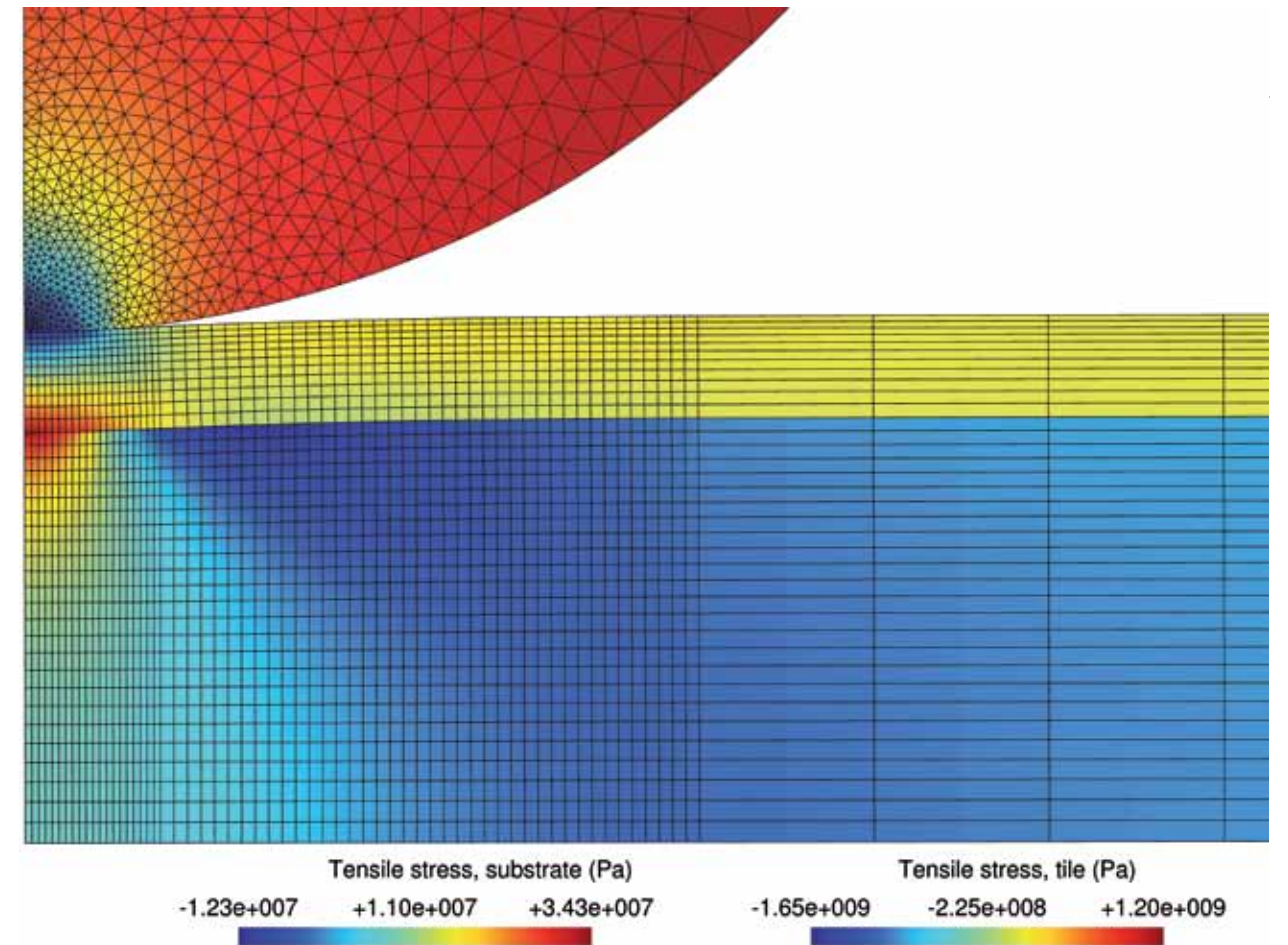
Heat transfer in roller kilns. Simulation allows temperature distribution inside the tile during the firing cycle to be ascertained. The input data are the thermal and geometric characteristics of the tile, as well as the kiln or tile surface temperature curve.

Calculation of curvatures and stresses produced by thermal gradients during firing. Related to the foregoing point, the temperature profile inside the tile enables tile stress distributions and curvatures during firing and at the kiln exit to be determined.

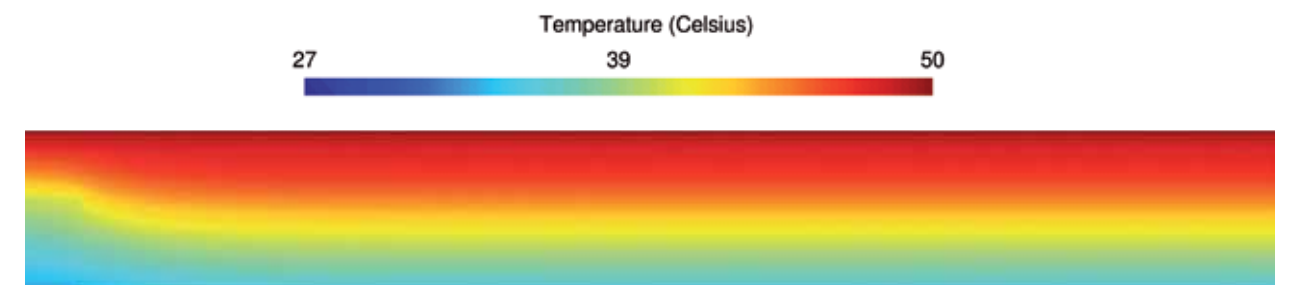
Simulation of materials mechanical performance. Materials are usually mechanically characterised on the basis of simple tests (three-point bending, compression, etc.), though they may be subject to different service stresses (edge-fastened tiles in ventilated façades, structural movement in directly adhered tiles, etc.). Using laboratory test data, simulation enables the arising service stresses to be determined.

Tile drying under industrial conditions. The evolution of tile moisture content during drying under industrial conditions can be established. This requires knowing tile temperature in the dryer, obtained using a temperature probe, and the characteristic ceramic tile drying parameters, measured in the laboratory. This information allows more efficient cycles to be designed, providing energy saving and an important reduction in product losses caused by breakage.

Crack propagation. The extended finite element method (XFEM) enables crack propagation in materials to be determined and, therefore, their mechanical performance to be established. This allows compositions and manufacturing processes to be designed, which yield products with better mechanical performance.



Dinámica no lineal: perfil de tensiones dentro de una pieza de gres porcelánico sometida a un impacto con una esfera de acero.



Thermal calculations: temperature profile inside a multilayer piece.

technical references

ITC has the capability to transfer the knowledge acquired through the ongoing training of its team of qualified human resources, who keep their knowledge up to date by conducting various R&D&I actions and studies, in addition to participating in numerous science and technology forums world-wide and in different international platforms and consortia. This knowledge, together with that acquired or assimilated from other production sectors, serves to generate the innovation that is transmitted to the companies, which need this to maintain or to enhance their competitiveness.

THE DISSEMINATION OF THE RESULTS OF THE STUDIES CONDUCTED BY ITC FROM THE OUTSET HAS LED TO 600 PUBLICATIONS OF SCIENTIFIC ARTICLES IN SPECIALISED JOURNALS, 700 COMMUNICATIONS AT NATIONAL AND INTERNATIONAL CONFERENCES, AS WELL AS THE DEVELOPMENT OF 31 PATENTS.

R&D&I projects co-financed with public funding

European Commission

KMM-NoE 502243-2 - Knowledge-based multicomponent Materials for Durable and Safe Performance (2004-2007).

Central Administration

BIA2009-10692 - Modelling and analysis of micro- and macroscopic stresses in glass-ceramic materials and their effect on strengthening / microstructural damage (2009-2012).

FIT-030000-2006-119 - Fractures in ceramic sheets comprising glass-ceramic substrates and stressed homogeneous layers (2005-2007).

FIT 380000-2005-159 - Design of a bioclimatic external ceramic building envelope with high energy efficiency (2005-2007).

Publications

CANTAVELLA, V.; GARCÍA-TEN, J.; SÁNCHEZ, E.; BANNIER, E.; SÁNCHEZ, J.; SOLER, C.; SALES, J. Curvaturas diferidas en gres porcelánico. Análisis y medida de los factores que intervienen. En: *Qualicer 2008: X Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. II, 2008, p. BC207-BC224.

CANTAVELLA, V.; MORENO, A.; FELÍU, C.; MUÑOZ, A.; BARBERÁ, J.; PALANQUES, A. Análisis del impacto mecánico sobre baldosas cerámicas. Factores que influyen. En: *Qualicer 2008: X Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. III, 2008, p. BC225-BC240.

CANTAVELLA, V.; MORENO, A.; MEZQUITA, A.; JARQUE, J.C.; BARBERÁ, J.; PALANQUES, A. Evolución de las tensiones y curvaturas en soportes porosos durante el enfriamiento. En: *Qualicer 2008: X Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. III, 2008, p. BC241-BC255.

DE NONI, A.; HOTZA, D.; CANTAVELLA, V.; SÁNCHEZ, E. Estudio de las tensiones residuales sobre las partículas de cuarzo en el gres porcelánico. En: *Qualicer 2008: X Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. III, 2008, p. Pos71-Pos73.

CANTAVELLA, V.; SÁNCHEZ, E.; DE NONI JUNIOR, A.; HOTZA, D. Influence of macrostresses and microstresses on the mechanical behaviour of porcelain tiles. En: HEINRICH, J.G. et al. (eds.). *Proceedings of the 10th International Conference of the European Ceramic Society*. Baden-Baden: Göller, 2008, p. 1810-1817.

CANTAVELLA, V.; MORENO, A.; MEZQUITA, A.; LLORENS, D.; BARBERÁ, J.; PALANQUES, A. Distribución de temperaturas en el interior de una pieza durante la cocción industrial. En: *Qualicer 2006: IX Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. II, 2006, p. BC151-BC164.

CANTAVELLA, V.; SÁNCHEZ, E.; GARCÍA-TEN, J.; IBÁÑEZ, M.J.; SÁNCHEZ, J.; SOLER, C.; SALES, J.; MULET, F.; MOR, S. Modelización de la operación industrial de pulido de baldosas cerámicas. En: *Qualicer 2006: IX Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. II, 2006, p. BC111-BC122.

CANTAVELLA, V.; MEZQUITA, A.; MORENO, A.; SILVA, G.; BARBERÁ, J. Modelling of the generation of residual stresses of thermal origin in ceramic materials. *Adv. Sci. Tec.*, 45, 83-88, 2006.

CANTAVELLA, V.; MORENO, A.; MEZQUITA, A.; REIG, Y. Modeling residual stresses in ceramic plates. En: PAULINO, G.H. et al. (eds.). *Multiscale and Functionally Graded Materials, AIP Conference Proceedings 973*. Melville, NY: American Institute of Physics, 2008, p. 712-717.

NONI JUNIOR, A. DE; HOTZA, D.; CANTAVELLA, V.; SANCHEZ VILCHES, E. Estudio de la influencia del enfriamiento sobre las propiedades mecánicas del gres porcelánico. XLVI Congreso de la Sociedad Española de Cerámica y Vidrio, Vall d'Alba (Castellón), 25-27 Octubre, 2006.

CANTAVELLA, V.; SÁNCHEZ, E.; IBÁÑEZ, M.J.; ORTS, M.J.; GARCÍA-TEN, J.; GOZALBO, A. Grinding work simulation in industrial porcelain tile polishing. *Key Eng. Mater.*, 264-268, 1467-1470, 2004.

CANTAVELLA, V.; MORENO, A.; MESTRE, S.; JARQUE, J.C. Elasticity and creep of fired ceramic tiles. 4th European Congress of Chemical Engineering, Granada, 21-25 Septiembre, 2003.

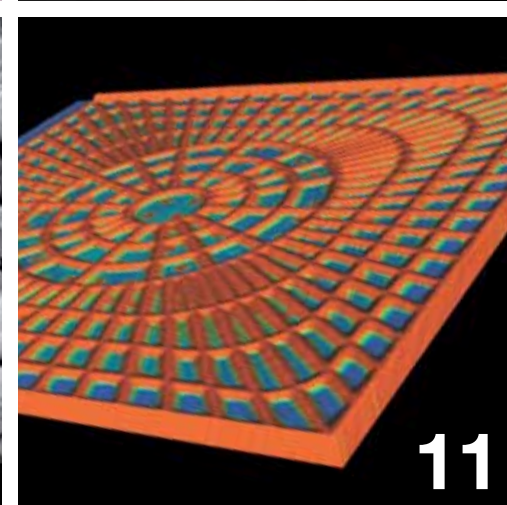
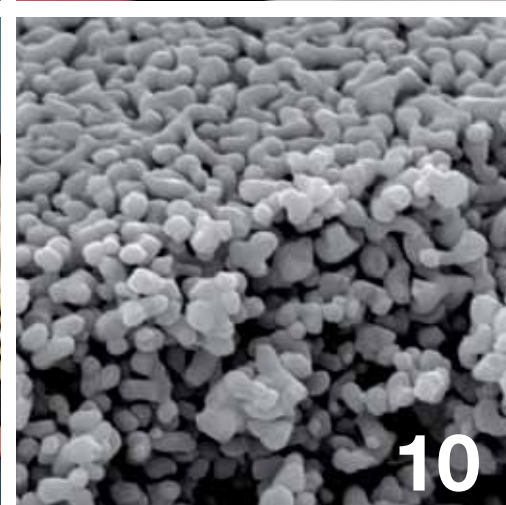
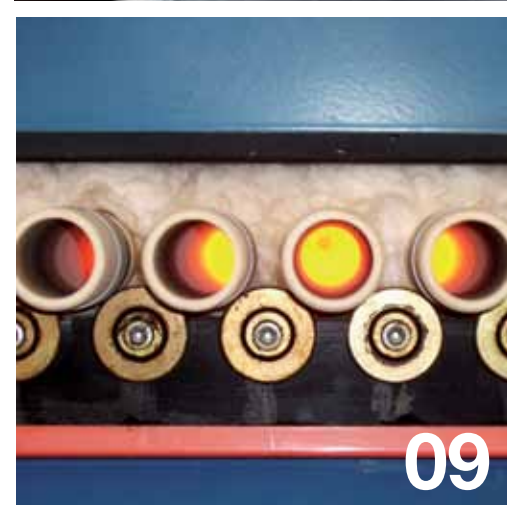
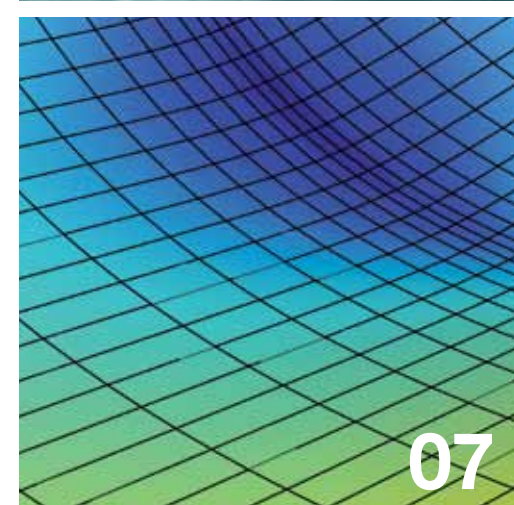
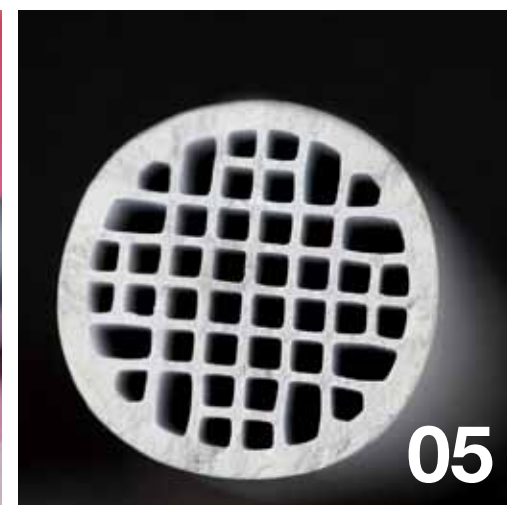
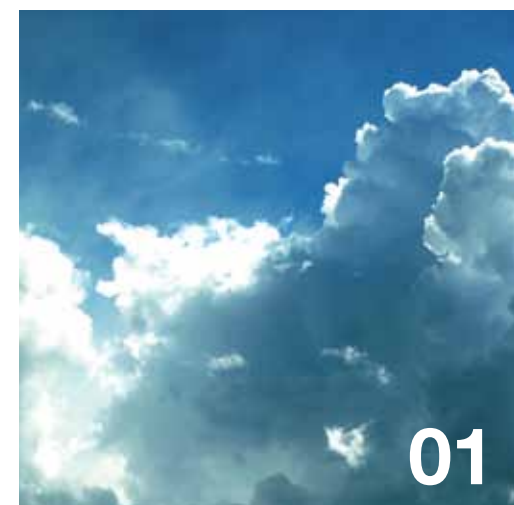
CABRERA, B.; GASCÓN, F.; JARQUE, J.C.; CANTAVELLA, V.; SEGARRA, C.; SILVA, G. Comportamiento de composiciones cerámicas frente al secado en condiciones industriales. En: *Qualicer 2002: VII Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. II, 2002, p. GI365-GI384.

SÁNCHEZ, E.; ORTS, M.J.; GARCÍA, J.; IBÁÑEZ, M.J.; CANTAVELLA, V. Wear mechanism in porcelain tile polishing. 103th Annual Meeting of the American Ceramic Society, Indianápolis (EE.UU), 22-25 Abril, 2001.

MALLOL, G.; CANTAVELLA, V.; LLORENS, D.; FELÍU, C. Study of ceramic tile drying under non-isothermal conditions and its industrial application. *Key Eng. Mater.*, 206-213, 1755-1758, 2002.

CANTAVELLA, V.; SÁNCHEZ, E.; GARCÍA-TEN, J.; FELÍU, C.; SÁNCHEZ, J.; SOLER, C.; PORTOLÉS, J.; SALES, J. Tensiones residuales en piezas de gres porcelánico elaboradas por prensado en doble carga. En: *Qualicer 2000: VI Congreso Mundial de la Calidad del Azulejo y del Pavimento Cerámico*. Castellón: Cámara Oficial de Comercio, Industria y Navegación, vol. II, 2000, p. GI 335-GI350.

-
- 01 Environmental technologies
 - 02 Occupational safety and health
 - 03 Tribology
 - 04 New coatings and surface treatments
 - 05 Advanced ceramics
 - 06 Construction systems and energy-efficiency for architecture
 - 07 Simulation of processes and materials
 - 08 Design
 - 09 Energy saving and energy efficiency
 - 10 Nanotechnology
 - 11 Smart manufacturing
-



8000m² SURFACE AREA DEVOTED
TO RESEARCH AND DESIGN SPREAD
OVER TWO HEADQUARTERS.



"All rights reserved. The content of this document enjoys the protection afforded by law and may not be communicated, transformed, reproduced, or publicly distributed, either wholly or in part, without the express authorisation of Instituto de Tecnología Cerámica-AICE ITC, 2010. © ITC-AICE, 2010.

Sede Central
Campus Universitario Riu Sec
Av. Vicent Sos Baynat s/n
12006 Castellón (Spain)

Sede Alicer
Av. del Mar 42
12003 Castellón (Spain)

www.itc.uji.es
info@itc.uji.es
T. +34 964 34 24 24
F. +34 964 34 24 25

