TECNALIA CAPACITIES RELATED TO ARCHITECTURAL ENVELOPES
INDEX

1. – ARCHITECTURAL ENVELOPES TEAM .................................................................................. 3
2. - MODULAR CONSTRUCTION TEAM ............................................................................... 5
3. - NATIONAL AND INTERNATIONAL PRESENCE ................................................................. 6
4. - TECHNOLOGICAL INNOVATION AUDIT (TIA) ................................................................. 7
5. - ARCHITECTURAL ENVELOPES LABORATORIES AND MAIN FACILITIES .................. 8
7. – KUBIK, EXPERIMENTAL FACILITY FOR ENERGY EFFICIENCY R&D AND
   DEMONSTRATION ............................................................................................................... 11
8. - INTERNATIONAL ARCHITECTURAL ENVELOPES CONGRESS .................................... 14
1. – ARCHITECTURAL ENVELOPES TEAM

The Architectural Envelopes Team, part of the Sustainable Construction Division, is a multidisciplinary group of highly qualified professionals which activities are mainly focused on:

- Technical assistance
- Innovation in products and systems
- Studies and projects review: energy efficiency, room acoustics and sound insulation, fire protection, structural analysis, dynamic wind load response and so on.
- Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD)
- Laboratory and "on site" tests for materials, products and building elements performance assessment. Test carried out according to national and international standards (EN, ASTM, AAMA and CWCT procedures…) or according to “tailor made” test protocols for innovative products.
- Inspections and surveys “on site”.
- Quality control.
- Some Representative works:
  - Ciudad de las Comunicaciones de Telefónica (Madrid)
  - New Airport Terminal (Barajas, Madrid)
  - Control Tower, Barcelona Airport (Barcelona)
  - Pórtilo Building, Campo de las Naciones (Madrid)
  - Diagonal Mar Tower (Barcelona)
  - Las Mercedes Business Center (Madrid)
  - Agbar Tower (Barcelona)
  - Sacyr-Vallehermoso Tower (Madrid)
  - Iberdrola Tower (Bilbao)
  - New City Council (Bilbao)
  - The Champalimaud Centre for the Unknown (Lisbon)
  - Business Center (Perpignan Train Station, France)
  - FKI Building, Seoul, Korea
  - Nueva sede BBVA, Las Tablas, Madrid
  - Torre Triana, Sevilla
  - King Abdullah Sports City, Jeddah, Saudi Arabia

![Image of architectural projects]
• **Patents related to envelopes**
  - Passive solar collector module for building envelopes
    - European patent application: 09812437.3, EP 2520 870 A1
  - Photovoltaic module for curtain walls and a curtain wall that includes such photovoltaic modules
    - Spanish patent application: P201031960
    - International Application number: PCT/ES2011/070902, WO/2012/089883 A2
  - Prefabricated façade
    - Utility Model application: U200930530, ES 1 071 274 U

**Experience on R&D projects**

In relation to R&D (research and development) projects, the Architectural Envelopes group included in the Sustainable Construction Division, has many years of experience in the field of facades, materials, sustainability, energy, environment and construction related collaborative R&D with European partners in competitive co-funded project by the European Commission.

These collaborative R&D is developed under the scheme of the Seventh Framework Programme (FP7) that bundles all research-related EU initiatives together under a common roof, playing a crucial role in reaching the goals of growth, competitiveness and employment; along with a new **Competitiveness and Innovation Framework Programme (CIP)**, Education and Training programmes, and Structural and Cohesion Funds for regional convergence and competitiveness. It is also a key pillar for the **European Research Area (ERA)**.

The broad objectives of FP7 have been grouped into four categories: Cooperation, Ideas, People and Capacities. For each type of objective, there is a specific programme corresponding to the main areas of EU research policy. All specific programs work together to promote and encourage the creation of European poles of (scientific) excellence.

Some of the related FP7 projects where this team has participated as coordinator or as a partner are:

- **SUSREF**: SUSTainable REFurbishment of Building Facades and External Walls (2008-2011);
- **MeeFS**: Multifunctional Energy Efficient Façade System for Building Retrofitting (2012-2015);
- **FACOMP**: Polymeric Nanocomposite profiles for curtain wall (FP7: Research for the benefit of SMEs);
- **IRCOW**: Innovative Strategies for high-grade material recovery from construction and demolition waste (FP7 ENV.2010.3.1.3-1);
- **OSIRYS**: Forest based composites for façades and interior partitions to improve indoor air quality in new buildings and retrofitting actions (EeB.NMP.2013-2. Safe, energy-efficient and affordable eco-innovative materials for building envelopes and/or partitions to provide a healthier indoor environment);
- **EINSTEIN**: Effective INtegration of Seasonal Thermal Energy storage systems IN existing buildings (2012-2015);
- **SPORTE2**: Intelligent Management System to integrate and control energy generation, consumption and exchange for European Sport and Recreation Buildings;
- **COST-EFFECTIVE**: Cost-Effective-Resource and Cost Effective integration of renewable in existing high-rise buildings (2008-2012);
- **MESSIB**: Multi-source Energy Storage System Integrated in Buildings (2008-2012);
- **ENPROVE**: Energy consumption prediction for decision support on infrastructure’s control Systems (2010-2013);
- **eDIANA**: Embedded Systems for Energy Efficient Buildings (2009-2013);
- **HREEB**: The European Strategic Research Roadmap to ICT enabled Energy-Efficiency in Building and Construction (2008-2010);
- **EARTO PREFAB**: Prefabricated multifunctional façade systems for building renovation (FP7)
• RETROKIT: Envelope toolboxes for systemic retrofitting (FP7-EEB-NMP-2012-2)
• SUPERBUILDINGS: Sustainability and performance assessment and benchmarking of buildings. FP7 Environment Collaborative project

2. MODULAR CONSTRUCTION TEAM

The team for industrialized structural construction products is a part of the Sustainable Construction Division. The group counts with a multidisciplinary team of high skilled professionals and its activities are mainly focused on:

• Development and assessment of solutions for structural safety
• Solutions to guarantee structural performance (robustness and resiliency) under accidents or natural disasters (fire or seismic situations)
• Development of industrialized construction of high buildings guaranteeing seismic and robust building performance
• Assessment and consultancy for structural design under wind dynamic loads.
• Implementation of industrialized construction procedures considering the manufacturing processes: tolerances, connections and durability.
• Specific design methodologies for steel, steel-concrete or wooden constructions according to integral sustainability and minimum performance criteria.
• Development of 2D and 3D modular solutions (CETICA, RMD, AMETSLAB, etc.) and improvement of connecting and joining systems for structural/thermal/acoustic performance (ECO-HOUSE, BALI…). Sustainability aspects are observed as well.
• “Portfolio of solutions” for industrialised modular, low cost, sustainable residential buildings

Experience on R&D projects

In relation to R&D (research and development) projects, the Structural-Industrialized construction products Team included in the Sustainable Construction Division, has many years of experience in the field of facades, buildings, acoustic, sustainability, energy, environment and construction related collaborative R&D with European partners in competitive co-funded project by the European Commission.

These collaborative R&D is develop under the scheme of the Seventh Framework Programme (FP7) that bundles all research-related EU initiatives together under a common roof playing a crucial role in reaching the goals of growth, competitiveness and employment; along with a new Competitiveness and Innovation Framework Programme (CIP), Education and Training programmes, research fund for Coal&Steel, and Structural and Cohesion Funds for regional convergence and competitiveness.

The broad objectives of FP7 have been grouped into four categories: Cooperation, Ideas, People and Capacities. For each type of objective, there is a specific programme corresponding to the main areas of EU research policy. All specific programmes work together to promote and encourage the creation of European poles of (scientific) excellence.

Some of the related FP7 projects and national projects where this team has participated as coordinator or as a partner are:
• CETICA. The eco-technological city. Industrialization of Steel for an improved sustainability in the urban environment.
• AMETSLAB: Industrialised construction with Eco technological modular architectures.
• ECOHOUSE: Industrialized construction method for collective residential wooden buildings
• BALI: Building Acoustic Living. Integrated design of systems and buildings made with modular solutions which are acoustically efficient and in a healthy environment
• SOSTENEA. Sustainable structural solutions for residential buildings made of Steel.
• CTEAE 3. Armonised effective implementation of the Spanish Technical Code (CTE), European Steel standard (EAE) and Eurocodes for Steel structures
• CONSTRUMAT. Design of construction modules and associated production methods for industrialization of buildings.
• STEEL CAR PARKS. Steel structures for underground parkings
• ISIS. Integrated research for sustainable Islands.
• MODCONS. Development of modular construction for sustainable design, stability and seismic applications.
• MEAKADO. Design of steel and composite structures with limited ductility requirements for optimized performances in moderate earthquake areas.
• HOSINGLAB: Innovative solutions for the hábitat. Industrialised low cost and sustainable buildings.

3. - NATIONAL AND INTERNATIONAL PRESENCE

• Organizers, with the Basque Country University, of “Master on light façades architecture” and member of “European Façade Network”, network of foundations and universities that organize master courses on façades.
• Organizers of International Congress of Architectural Envelopes (ICAE) (www.icae2012.com/en/)
• Participant in the European Committee of Normalization (CEN), Technical Committee 33, Working Group 6 “Curtain Walling” experts (Julen Astudillo and Miguel Mateos)
• Members of EARTO “European association of Research and Technology organizations”
• Members of ECTP “European Construction Technology Platform”
• Members of ASEFAVE “Spanish Association of Manufacturers of Light Façade and Windows”
• Spanish Steel Technology Platform Construction Committee Chairman (PLATEA, http://www.aceroplatea.es/ )
• AENOR (NATIONAL)
• AEN/CTN-140/SC1 Structural Eurocodes - Actions on structures
• AEN/CTN-140/SC3 Structural Eurocodes - Structural Steel
• AEN/CTN-140/SC4 Structural Eurocodes - Mixed Structures
• AEN/CTN-140/SC9 Structural Eurocodes - Aluminum Structures
• AEN/CTN-140/GT6 Structural Eurocodes - Structural Robustness
• AEN/CTN-140/GTGHP Structural Eurocodes - Horizontal Bridge Group
• Spanish representative in the EC3 of CEN/TC-250/SC3 EG
  o Part 1-1 General and Building (no meeting)
  o Part 1-9 Fatigue (a meeting in Portugal that I could not go, is done with the 1-10)
  o Part 1-10 Split (a meeting in Portugal that I could not go, is done with the 1-9)
  o Not confirmed, Spanish representative in the CEN/TC-250/SC4 EG's EC4
4. - TECHNOLOGICAL INNOVATION AUDIT (TIA)

This service allows evaluating the technical characteristics of a product under development, both through documents as by testing prototypes. This service analyzes the technical maturity of the product along with the process to be followed for it to be integrated into the market, classifying it into three states:
1. Go to market
2. Repair
3. Stop

ADVANTAGES
- Technological Risk Reduction.
- Reduced investment costs.
- Advancement of the product arrival to market.
- Documentary evidence for application to R&D calls to improve the suitability of the product.
- Setting Product Development to meet with existing regulations across Europe.
- Pre-Document until the product obtains its final evaluation to assess the compliance of the final specifications, such as Conformity Technical Report (TC), ETA guidelines, harmonized standards, etc.

TASKS RELATED TO TECHNOLOGICAL INNOVATION AUDIT (TIA)
- Identification of the current regulations for the use defined by the manufacturer.
- Documental verification or by testing a prototype to assess the aspects covered in the normative framework established by the Technical Building Code (CTE) in Spain:
  - Structural Safety (snow loads, wind ...)
  - Safety in case of fire
  - Security and accessibility safe
  - Salubrity
  - Protection against noise
  - Energy saving (energy efficiency, RITE)
- Documental verification or by testing a prototype to assess the aspects covered by other legislation in relation to the market - Product target country.
- Sustainability Criteria (Environmental Product Declaration) according to the new regulations of the Construction Products, "Cradle to Cradle".
5. - ARCHITECTURAL ENVELOPES LABORATORIES AND MAIN FACILITIES

FACADES AND CURTAIN WALLS
- Types of technological services does a façades laboratory offer
  - Assessment of Weather resistance test of system
  - Mechanical characterization of its components
- How is the laboratory's activity recognised?
  - The Quality Management System implemented following international standards such as ISO 17025 allows for notification within the context of the CPR.
- Essential equipment of the façades laboratory
  - Weather resistance test rig:
  - Force application systems
  - Dynamic wind generator
  - Seismic test rig
  - Thermal cycles rig
  - Ventilated façades rig
- Who is the target customer of a façades laboratory?
  - Manufacturers or specialised shops of:
  - Façades and curtain walls systems and their components
  - Contructoras y promotoras
- What can we offer from tecnalia?
  - Significant historical development as test laboratory
  - International renown
  - Professional experience of our staff
  - Independence and integrity of our activities
  - Thorough knowledge of standards and regulations

GLASS AND GLASS PRODUCTS SERVICES
- We carry out tests in order to obtain certificates complying with standards in force
- Analysis of failures and their causes in glass in Building
- Characterization of special glazing
- Research on the behaviour of glazing when faced with specific climatic and mechanical requirements

Glass in buildings
Tecnalia assesses and supplies specific technological services for the glass industry:
- Float glass,
- Patterned glass,
- Coated glass,
- Laminated glass,
- Insulating glass units,
- Glass for special solutions,…

Likewise, we assess another glass products like glass for railway and sea transport and glass for internal partitions, handrails and footbridges.

**TESTS:**
- Mechanical tests: fragmentation test of thermally toughened glass and heat strengthened glass, compression strength measurement, mechanical strength measurement in accordance with EN 1288-3:2000, features of safety in use being especially noteworthy: resistance to impact (pendulum) in accordance with EN 12600:2002 and resistance to manual attack in accordance with EN 356:1999 (hard body drop test and axe attack test).
- Durability of laminated glass: humidity, high-temperature and radiation tests in accordance with ISO 12543-4:2011
- Fire resistance EN 357:2004 and reaction to fire of laminated glass and insulating glass units EN 13501-1:2007
- Thermal transmittance in accordance with EN 673:2011 and EN ISO 8990:1996
- Airborne sound insulation in accordance with EN ISO 10140-2:2011

**NOTIFIED BODY No. 1292**
TECNALIA is notified body No. 1292 to carry out tests for CE marking of glass products in accordance with Directive 89/106/EEC which lays down harmonized conditions for the marketing of the construction products.
THERMAL LABORATORY

SERVICES

- Evaluation of thermal insulation properties and thermal resistance of building materials and elements
- Characterization of thermal insulation
- Determination of thermal properties by testing or simulation
- Determination of thermal bridges and infiltration in buildings ("in situ" tests)

EQUIPMENT

- Test bench for determining thermal conductivity and thermal transmittance:
  - Hot Box for construction elements
  - DAC: hot plate meter for thermal insulation
  - Climatic chambers
- Computer program based on the finite-element method.
- Thermographic camera and monitoring equipment
- Blower-door

CLIENTS

- Manufacturers / traders of building elements:
  - Insulation materials
  - Aluminum, PVC or wooden windows
  - Façades and curtain walls
- Designers
- Building firms
7. – KUBIK, EXPERIMENTAL FACILITY FOR ENERGY EFFICIENCY R&D AND DEMONSTRATION

KUBIK is a distinctive and unique world-class experimental R+D+i installation designed for the development of new concepts, products and services for the improvement of building energy efficiency.

KUBIK is aimed to the development of new concepts, products and services to improve the energy efficiency of buildings.

The main characteristic of KUBIK is the capability to build realistic scenarios to analyse the energy efficiency obtained from the holistic interaction of the constructive solution for the envelope, the intelligent management of the climatisation and lighting systems and the supply from renewable energy sources.

The R&D infrastructure consists of a building able to provide up to 500 m² distributed in an underground floor, a ground floor and up to two storeys; the main dimensions are 10,00 m. width x 10,00 m. length x 10,00 meter high (plus and underground floor 3,00 m. depth). The supply of energy is based on the combination of conventional and renewable energy (geothermic, solar and wind). In addition, the building is equipped with a monitoring and control system which provides the necessary information for the R&D activities.

KUBIK’s main structure provides an experimental, adaptable and reconfigurable infrastructure to create the indoor environments to analyse and to allow the assembly of the constructive solutions for the envelope, floors and partitions which performance must to be assessed under realistic conditions.

The design of KUBIK is based on an industrialised approach to achieve a flexible and adaptable experimental facility, an open building-system, to evaluate and optimise new construction components and solutions, systems and services for the improvement of building energy efficiency.

MONITORING AND MANAGEMENT SYSTEM

All the flexibility required to KUBIK aims to provide a R&D infrastructure able to perform diverse scenarios and to capture the necessary information to carry out the analysis and assessments.

The infrastructure has up to seven individual measurement rooms; one control room and one service room per each of the three floors, see Fig. 9. It provides the possibility to combine some individual rooms into a unique measurement room if it is required by the experiment it and also allows to have all the three floors as a unique building, for example an specific office, school, etc..... This flexibility is possible thanks to the structural design and to the services design: each individual measurement room has the climatisation, power and data network that needs to build an scenario.

The Figure 9 shows the nine rooms of each floor with the electrical and data network: the individual measurement rooms are: N1, M1, M2, M3, S1, S2 and S3; the control room is N3 and the service room is N2. Figure 6 shows too an example of a possible layout of one floor: three individual measurement rooms (N1, M1 y S1) and one combined measurement room (a combination of M2, M3, S2, and S3) and their respective HVAC system.
Captions:
Blue boxes: sensor at floor level
Pink boxes: sensor at ceiling level
Brown boxes: power electricity

Equipment by each individual measurement rooms. A floor integrated sensor box is showed in Fig. 4.
The monitoring and management system is integrated in an intelligent energy system (IES) which optimizes the
energy consumption of the building satisfying each measurement room needs. IES manages the HVAC system (heat
and electricity demand and production equipments), the lighting system and the supply from renewable energy
equipments, see Fig. 10.

Monitoring and management system integrated in an intelligent energy system. Some sensors are shown below the
schemes, from left to right: Diffuse solar radiation, solar radiation and weather conditions.
The monitoring system is in charge of data gathering and management tasks and to provide comprehensive
information necessary for the analysis along. It collects data from the: measurement system; building automation
system, HVAC control system and external meteorological conditions.
The monitoring system is equipped with over 800 sensors that records conditions inside and outside, weather
conditions, the experimental facility. Researchers have access via the Internet to measurements being taken. The
The test measurement system includes the following sensors: indoor air temperature, surface temperature, radiant temperature, humidity, air velocity, heat flux, solar irradiance, luminance, CO2 concentration, sound level meter. The building automation system includes sensors for: shading control, blind control, lighting control, open/close window control, open/close openings control. The HVAC control system includes the following sensors: air temperature, relative humidity, air velocity, air/water temperature, air/water flow, air/water temperature flows, energy consumption of auxiliary equipment (fans, pumps). The external meteorological conditions are defined by: air temperature, humidity, solar irradiance, wind direction, wind velocity, precipitation and atmospheric pressure.

The experimentally-obtained results enable diagnoses and proposals for potential product/concept design improvements to be made and the thermal/energy performance.

The chosen measuring and management system is based on a PLC platform with Windows Embedded technology allows simultaneous scenarios analysis as well as with different requirements, boundary conditions. The PLC layer of the control system is in charge of gathering data from the sensors and writing commands into the remote actuators, not only this but the PLC layer processes update the central database with the sensor and actuator values.

On the other hand, the Windows layer hosts the developments done in order to analyse different energy efficiency policies, e.g. will be dedicated to energy efficiency developments from a holistic approach, this means taking into account not only the potential energy demand reduction but considering, too, the storage and generation capabilities deployed in the KUBIK.

Left, architecture of the monitoring and management system and, right, concept for the measuring and management system.

The technology used to build the energy efficiency algorithms is based on expert systems development platforms as Jess (Java Expert System Shell) and Hybrid Finite State Machines (Hybrid FSM). Both technologies are in the domain of the intelligent agent development field. The background for both technologies is that they are based on the skills to simulate complex scenarios and not only simple state transitions. Those skills are used to model scenarios in which user behaviour and preferences, outdoor and indoor conditions, altogether, are factors in order to take a decision.
8. - INTERNATIONAL ARCHITECTURAL ENVELOPES CONGRESS

Every three years the Facades group of Tecnalia organizes an International Congress related to facades, their integration on the building, their design, their relation with the production and consume of energy, new materials, technologies, etc. A summary of the last edition is explained below:

July 2012 – The Sixth Edition of the International Congress of Architectural Envelopes was held in San Sebastián-Donostia from 20th to 22nd June. This edition was centered on innovation and the identification of future challenges with regard to architectural envelopes. Over 230 researchers attended the congress: industrialists, and architects from Latin America, the United States, and various European countries such as France, the United Kingdom, Germany, Switzerland, Greece, Holland, and Spain.

Congress participants included architectural and engineering studios as prestigious as Herzog & de Meuron, UNStudio, Pelli Clarke Pelli Architects, Eckersley O’Callaghan, Estudio Lamela, Ortiz y León Arquitectos, Inhabit Group, and Knippers Helbig Advanced Engineering, among others.

Over three days a panel of more than 50 congress participants, including members of the International Scientific Committee and representatives from various countries, expounded the main achievements, challenges and architectural projects on the topic of envelopes, among which those presented in the first session (and part of the second) were summarized in a publication of congress proceedings that was circulated to all participants.

The topics addressed in the plenary lectures, parallel sessions, round tables and working groups were very diverse: new materials for use in facades, new design methodologies and constructive systems, calculation systems, possibilities of the envelope from the perspective of rehabilitation, need for the use of double skins, the future of the envelope, etc. Several buildings (principally in Asia) were also reviewed with unique envelopes; buildings presented by the architectural studios responsible for their design.

One of the most relevant achievements of the congress was to bring together a varied group of researchers, industrialists and professionals from various disciplines to approach the study of envelopes from varied perspectives. The international meeting also stands out for having created the opportunity for the exchange of experiences and interaction between participants. This interaction allowed similar concerns to be shared on the “distressing state” of the sector and the transformation that it is going through: new markets, internationalization of national and European companies, new possibilities for development, etc.

One of the most important challenges facing the congress was how to convey the importance of research and development in the world of the envelope to participants and how to apply this research to decision-making in their work and in their new products. There was also talk of innovation and its relation to the market, as one of the supports to facilitate growth in view of the plight of the national market.

The congress likewise served to acknowledge the worth of various actors that participated in the value chain, ranging from architectural and engineering studios, through to industrialists and universities and technological centres. By doing so, it strengthened the capabilities to link research and development with the search for new effective solutions to various facade-related problems (pathologies of materials and construction systems, design problems, etc.) which enriches perspectives, strengthens capabilities and boosts the search for solutions.
This edition of the congress enjoyed the collaboration and support of the Asociación Española de Fabricantes de Fachadas Ligeras y Ventanas [Spanish Association of Manufacturers of facades and Windows Light] (ASEFAVE), the architectural journal DETAIL and the Basque Government through its Department of Education, Universities and Research. Moreover, companies such as REYNAERS, GUARDIAN, SIKA, TECHNAL, 3M, EA, VMZINC and LANIK sponsored the congress, which has contributed to the growth and consolidation of the architectural envelopes sector.