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INTRODUCTION

This manual is the result of the Leonardo da Vinci project titled: **IMPROVING VOCATIONAL EDUCATION IN THE CONSTRUCTION INDUSTRY SECTOR WITH THE AIM OF IDENTIFICATION AND RECOGNITION QUALIFICATIONS IN EUROPEAN UNION COUNTRIES 2008-1-PL1-LEO05 -02059.**

Polish Association of Construction Industry Employers – Poland was the promoter of the project.

Partners of the project: Polish British Construction Partnership Sp. z o. o. – Poland, CREDIJ (Centre régional pour le développement la formation et l'insertion des jeunes) – France, University of Minho – Portugal, Ufficio Scolastico Provinciale di Venezia – Italy, Econometrica Ltd. – Greece, The Chartered Institute of Building – United Kingdom.

PROCONSTR was the project concerning developing an innovative program of vocational trainings based on eight selected construction professions for graduates from vocational schools and technical secondary schools and employees who are professionally active and want to increase their skills.

Aim of job modules was to promote idea of regular vocational development, support activities leading to implementation of European tools concerning education and vocational training – equalization of opportunities on European labour markets, intensification of cooperation among companies from construction sector and social organizations in order to promote vocational development with reference to EQF and ECVET in the Europe.

Moreover project's challenge was to make participants in the trainings aware of requirement of increasing their vocational qualifications due to regular trainings, learning new techniques and technologies utilized in construction industry and language education since gaining these skills and especially, language skills gives them opportunity of being employed in the whole territory of the European Union.

Unification of essential regulations of vocational qualifications in European Countries might simplify easy transfer of the most modern technologies as well as it would enable common usage of knowledge and generate new employees able to meet requirements of contemporary European market.

Nature of trainings were directed into men and women, due to this fact supporting efforts heading for equalization of opportunities of access to vocational education and ensuring equality on the labour market, in this case, giving special consideration to the construction branch.

Outcome of the project is an innovative didactic material for beneficiaries. Eight job modules were created on the basis of collected data and domestic markets available didactic materials with support of construction companies on national levels.

- **Job Module for Bricklayer**
- **Job Module for Carpenter**
- **Job Module for Plumber**
- **Job Module for Electrician**
- **Job Module for Concrete builder**
- **Job Module for Roofer**
- **Job Module for HVAC worker**
- **Job Module for Plasterer**
- **Module for trainer**

Each job module consists of two parts – first one – theoretical including the latest know-how concerning specific trade necessary for an employees and second one – training part with appropriate examples and set of exercises based on chosen innovative aspects.

Project's creators head for the situation, in which the final product might have a long-term influence and would be exploited successfully in vocational education in the whole territory of the Union. Exploitation of unified pack of vocational trainings in all countries would result in elimination of formal and informal barriers concerning easy-flow of employees and equalize differences in professional qualifications level.

Equalization of qualifications between highly and low developed countries would result in effective experiences exchange; simplify identification of different types of problems (in lower developed countries) and implementation of preventive means.

Conclusions made from executed project could be utilized in order to create new training solutions as well as to prepare vocational education system reforms on a domestic level.

More information on project website: www.proconstr.eu.

INFORMATION ABOUT THE COURSE

Participants should have the following prerequisite knowledge concerning concrete building prior to attending this course.

The innovation you will learn at the course concerns fibre reinforcement concrete. After a presentation of the mostly used reinforcement fibres, the course will more specifically deal with the use of steel fibres for concrete reinforcement

Generically, the use of fibre reinforcement in the concrete mix has several advantages, namely the improvement of several concrete properties (cohesion, freeze-thaw resistance, explosive spalling, impact resistance, plastic shrinkage and so on), the reduction of steel reinforcement requirements and the improvement in ductility. Beyond accomplishing these features, steel fibres have additional advantages, namely, the improvement of structural strength and impact / abrasion resistance.

As a participant, you will gain knowledge about different types of fibres that can be used for concrete reinforcement and you will further learn about steel fibres.

After the course you will be aware of the use of fibres for improving concrete mixtures and for rehabilitating of concrete structures, identify different types of fibres for concrete reinforcement, be familiar with the production process for steel fibre reinforced concrete, be able to incorporate steel fibres in the concrete mix, comprehend how to use testing devices for monitoring workability of the fresh concrete mixture.

As a participant you will receive a manual and a CD containing all necessary didactic materials. You will be asked to participate in the theoretical lectures and practical workshops conducted by a vocational trainer. Moreover you gain knowledge how to read and use additional materials included in this course.

Your knowledge will be tested/assessed by a trainer with use of the set of questions at the end of the course.

After completion of the course you will gain **PROCONSTR CERTIFICATE**.

PREFACE

The PROCONSTR project is intended for two main groups of construction workers; qualified workers and medium-level technical supervisors. Eight trades covered by the project represent the main professions of a large cubature house building sector as well as the infrastructure sector that constructs office buildings, hotels, commercial, cultural and sport centers, healthcare infrastructure and other public utility buildings. Experts in the fields covered by the project are also crucial for the single-family house building sector. They are equally important in the industrial and road construction sector.

Traditional trades like: concrete builder, carpenter, reinforced concrete builder, mason, roofer, and plumber are currently undergoing a dynamic evolution due to the technical progress in the construction field.

The common use of concrete pumps together with concrete mixers and widespread application of chemical products in construction such as self levelling floor compounds and resin are an important part of the prefabricated reinforced-concrete elements which are used for ceiling construction. Common use of prefabricated reinforcement elements such as meshes and cages has been an important influence on the change from the traditional idea of seperate concrete and reinforced concrete builders. Joining the two trades together creates a more universal trade for the reinforced concrete builder.

The widespread application of formworks and scaffolding used on all types of construction sites has a decisive influence on the ongoing changes in the profile of the carpenter’s profession. Similarly, an exceptionally wide range of roof coverings and new methods of assembling makes a crucial impact on the modern definition of the profession of a roofer. Important changes are happening in the field of masonry, where masons are required to have an in-depth knowledge of all types of plasters and glues. The knowledge of an electric fitter has to cover a wide range of low current electric installations. A trade which is currently undergoing particularly dynamic changes due to a huge progress in the field of air conditioning techniques is the HVAC fitter.

Equally, significant progress can be seen in the field of sanitary techniques. A whole range of equipment is available on the market that has not been used before. The use of internal or external materials made of epoxy resins, carbon fibres and other synthetic materials has already exceeded the percentage use of traditional materials. The introduction of different types of plaster, dry walls or other wall elements like cardboards, significantly widens the requirements relating to the trade of a plasterer.

Apart from technological changes that have influenced the profile of vocational training, it is impossible not to mention general requirements which have to be fulfilled by modern construction teams.

These requirements include:

- a significant shortening of the project implementation cycle
- limiting the area of construction sites, particularly in urban agglomerations

- the expansion of vertical-building projects
- the introduction of a top-down method, i.e. a simultaneous construction of both the underground and ground structures
- carrying out the works in extreme weather conditions, due to the possibility of putting concrete layers at both low and high temperatures

Nonetheless, health and safety at work is the most important issue, relating to both the dynamics of changes in vocational profiles and strict requirements.

The expansion of the European Community favors the free movement of services in the construction sector. This reinforces the creation of construction companies with international capital. It also creates the need for mobile construction teams, which together with the high quality requirements constitutes an incentive for the unification of qualification of construction workers on the highest level in the whole Union. The aforementioned reasons underline the importance of changes undergoing in the field of construction trades.

A good economic situation for the construction market affects economic development substantially. Demand for residential housing, office space and infrastructural building increases. Orders placed by investors motivate contractors to carry out their jobs and the contractors stimulate enterprises manufacturing building materials to maximize their production capacities; it enables quick completion of construction investments. Consequently, a system enabling stimulation of economies and decrease in the unemployment rate is launched.

When a market presents a demand for a quick and thorough carrying out of investments, the most serious problem there is finding a relevant contractor team consisting of high-class specialists knowing all aspects of a profession and that are trained to the latest methods and technologies used within the construction project, in particular, in fields of their specialization.

Chapter I - INTRODUCTION TO CONCRETE BUILDER TRADE

Traditional Trade

Traditionally, concrete builders deal with all aspects related to fabricating the constituent elements of concrete structures, namely, foundations, columns, beams, slabs and so on. In doing so, concrete builders first set the formwork for containing fresh concrete, place the reinforcement, if required, cast the fresh concrete mass into the formwork and finish up the surface. Moreover, each of the preceding basic operations comprises a set of elementary relevant tasks:

a) To construct the formwork by using raw materials (wood sheets and beams, most commonly) and prefabricated materials (plywood, timber board, etc.), nails, steel struts and so on. The formwork should be previously inspected, cleaned, oiled, tightly secured with minimal leakage and carefully aligned so that the element to fit in acquires the final dimensions established on the design drawings. Alternatively, formwork proprietary systems may be used in which case the assembly procedure set up by manufacturer must be followed. This task implies the correct interpretation of the design documents and the alignment of the formwork accordingly. In the end, the formwork is disassembled and stacked according to size and quality.

b) To set up the reinforcement of concrete elements if necessary. For traditional steel reinforcement, this implies previous cutting, bending and pre-assembling of steel bars, according to the types and sizes prescribed in the design documents (mostly drawings). Setting up the reinforcement implies fitting it into the formwork (pre-assembled reinforced steel make-ups, pre-cast steel grids, leaves for installing post-tensioning cables, etc.) and fixing it according to the location and spacing established on the design drawings and applicable standards.

c) To place the fresh concrete into the formwork and cast it properly by using appropriate techniques (like vibration) and tools (like shovels, mass vibrators, surface vibrators, etc.) thereby ensuring that the material adequately fills in the formwork without voids. The correct design mix must be assured and the appropriate curing methods applied. To facilitate removal, the internal faces of the formwork in contact with the fresh concrete mass must be painted with appropriate products (otherwise, some bits of concrete may remain stacked to the formwork surface and the concrete face will become damaged).

d) To spread fresh concrete by using appropriate tools (like rods, shovels, etc.), and to level and smooth the surface (with manual and mechanical tools like trowels and bull floats) for receiving a finishing layer or for being used as a finishing surface.

e) To assemble pre-fabricated concrete elements (like columns, beams, etc.) by using mechanical leverage equipments, jacks, steel cables and other tools and to fit them accordingly within the structure. This task implies knowing how to operate the mechanical equipments used in the process of lifting the concrete elements to their final positions, balancing the strength and precision needed in this process, understanding the connecting approach adopted by the pre-fabrication system being used and dominating the technique for actually performing the connections accordingly.

To proficiently complete these tasks, concrete builders must have certain workplace skills, knowledge, and experience. Workers must know how to: interpret the information contained in the design documents, technical specifications and work method statements; clearly understand the methods and characteristics of the tasks to be performed; estimate quantities of material and tools to perform the work and set up resource requirements if needed; select and use a variety of equipments and tools to manipulate the different materials and components (wood, steel, cement, etc.) and to carry out the tasks; comprehend the composition and behaviour of concrete; deal with field conditions and monitor the wind, heat, and temperature that can severely affect the durability of the final concrete structure; inspect the quality of the work performed so as to fulfil the provisions of the specifications and take appropriate measures when non-conformities are detected in accordance with standard norms. Concrete builders must also know how to identify site conditions, plant location, material storage and collaborate in organising the site; carry out housekeeping (including cleaning and maintaining work tools and machinery in good condition) and waste management operations; execute tasks according to project work schedule and coordinate them in conjunction with other running activities; liase with site management and contractors on progress of works, health and safety issues and report on work progress, accidents, near misses and unexpected difficulties. Finally, all the tasks must be prepared and organized according to the general foreman's or site manager's instructions and according to technical drawings, method statement and specifications, applicable standards, norms and codes and other requirements such health and safety, environmental, waste, quality and other relevant requirements

All these tasks are performed in a work environment of this trade is somewhat demanding as it requires continuous physical stamina due to the fast paced and strenuous nature of the work, e.g. prolonged standing, bending, lifting and carry heavy objects. Workers have to get used to variable schedules and work overtime due to, for instance, continuous concrete placement and coordination with other specialties involved in the project. Working in areas of constricted movement, exposure to changing weather conditions, noise and other many hazardous risks (e.g. working with potentially dangerous tools and equipment, working at heights, etc.) is common.

Accordingly, safe working conditions and habits are constantly emphasized by employers to lessen work-related injury and illnesses. The use of collective and individual safety equipment is very important in this trade. Workers must accustom to wearing long pants, long-sleeved shirt, gloves, rubber boots, safety vests and hardhats. Also other protective devices like safety goggles, face shields, dust masks / respirators, ear plugs, should also be used according to the task at hand. Furthermore, setting up safety procedures such as individual harnesses, collective fall protection systems, guardrails around excavation openings for working heights, assembly and handling of ladders and scaffolding to avoid overloading and collapse; constantly checking equipment and tools to ensure they are in proper working conditions are common practice on-site.

Workplace organisation and ergonomics are equally imperative to lessen health burdens. Workers must be aware and keep the jobsite clean to prevent slips and falls; use material handling equipment (e.g. fork lifts, cranes, hoists, pallet jacks or carts) to move heavy materials or containers; lift objects by bending knees instead of back; set up work so it can be done above the knees and below the shoulders. (i.e., on a waist-level work table or saw horses); use powered and non-powered hand tools in such a way as to reduce awkward postures, forceful exertions, contact stresses, and vibration, and so on.

Professional development

Concrete workers usually acquire skills through work experience and training on-site where the informal instruction is given by experienced workers that teach how to use the tools, equipment, machines, and materials of the trade. Further qualifications may be acquired by attending [1]: professional courses; apprenticeship courses; specialised technological courses; certified modular training; education and training courses for young persons and adults at national or international level (these modalities are known as "double certification training") covered under the National Qualifications Catalogue[2]. Qualifications can also be obtained by recognition, validation and certification of skills acquired through other professional training and personal lifelong experiences and also by recognition[3] of credentials acquired in other countries. After an individual has proven to have acquired the necessary vocational skills, a training entity (recognised by the National Qualifications System and/or Certifying Body) issues a Qualification Certificate, Course Diploma or Vocational Aptitude Certificate according to the type and level of training undertaken. Skills may also be registered in the Individual Booklet of Competences which is an official, personal, non-transmissible and optional document, allowing individuals to present their training and competences acquired throughout their life, as well as giving employers an easier way to ascertain the appropriateness of the competences of the candidates to the work posts.

[1] In Portugal, professional training is regulated by Decree-Law nº. 396/2007 of 31st December 2007 which sets up the legal framework of the National Qualifications System (NQS) (i*n PT: Sistema Nacional de Qualficações - SNQ*). The SNQ articulates the vocational training included within the Educational System and Labour Market and establishes common objectives and fundamental supporting instruments, namely [200][201]:

- **National Qualifications Framework** which defines the structure of the qualification levels, based on the principles of the European Qualifications Framework;
- **National Qualifications Catalogue** which integrates qualifications based on competences, identifying for each competence the corresponding competence references, training and level of qualification in accordance with the National Qualifications Framework;
- **Documents** to register/compare qualifications and skills (i.e. Individual Booklet of Competences)**.**

[2] The National Qualifications Catalogue (NQC) (*in PT: Catálogo Nacional de Qualificações – CNQ*) is an instrument developed in close with the European Qualification Framework for Lifelong learning (recommendations (2008/C111/01) of the European Parliament and of the Council of 23rd April 2008). In Portugal, the Concrete/ Reinforced Concrete Builder is classified in the NQC under subgroup 7.1.2 – Civil construction and public Works Labourers. Sub-categories include: 7.1.2.3.05: Concreter; 7.1.2.3.10: Steel fixer; 7.1.2.3.15: Concrete Vibrator Operator; 7.1.2.3.30: Pre-stressed Concrete Installer; 8.2.1.2.05: Concrete mixer operator; 8.2.1.2.02: Concrete Installation Operator.

[3] In Portugal, the recognition of titles is the responsibility of the National Agency for Qualification (*in PT: Agência Nacional para a Qualificação - ANQ*), when not covered under the Directive 2005/36/EC of 7th September 2005 regarding the recognition of professional qualifications in Europe.

Chapter II - LEGAL BASIS

The concrete builder's activities specified in Chapter I are in conformance with the following legal basis in each of the partner countries.

In Portugal

Labour Law: The Labour Code in Portugal is regulated by Law n. 7/2009 of 12th February. Further information regarding construction works contracts may be found in the Collective Work Contracts in the Construction Sector (*CCT, Contratos Colectivos de Trabalho para o Sector da Construção)* published by the Ministry for Labour and Social Solidarity in the Employment and Work Bulletin (*Boletim do Trabalho e Emprego)* n. 12 of 29th March 2009.

Standards for the Small and Middle-size Enterprises (SME): There are no specific regulations for SME. For the construction and real-estate companies there is a regulating entity (the Construction and Real Estate Institute -*in PT, Instituto da Construção e do Imobiliário, INCI*) and specific regulations concerning the admission and practice activity, namely:

- Decree-law n. 12/2004 of 9th January 2004 establishes the legal framework for the admission to and permanency in the construction activity;
- Decree n. 19/2004 of 10th January 2004 establishes the categories and subcategories related to the construction activity;
- Decree n. 21/2010 of 11th January 2010 establishes the value of the construction works according to the qualification categories of the building permit for 2010;
- Decree-law n. 211/2004 of 20th August 2004 regulates the real estate activity.

Basics of construction standards: General Regulations of Urban Buildings (*in PT: Regulamento Geral de Edificações Urbanas, RGEU*) approved by Decree-law n. 38382 of 7th August 1951 (modified by Decree n. 38888 of 29th August 1952 and further revisions). A new version is foreseen to be published soon (*in PT: RGE*).

Basics of construction Works Contract: For general contracts, the Civil Code approved by Decree-law n. 47344/66 of 25th November 1966 (1st version) and for public contracts, the New National Public Procurement Code approved by Decree-Law nº 18/2008 of 29th January 2008 (modified by Decree-law n. 278/2009 of 2nd October and Decree-law n. 223/2009 of 11th September).

Health, Safety and Welfare Regulations: Decree 41821 of 11th August 1958 establishes the work safety regulation for building construction; Decree-law 441/91 of 14th November 1991 establishes the general principles for the promotion of Health, Hygiene & Safety at work (transposes Directive n.º 89/391/CEE of 12th June); Decree-law 273/2003 of 29th October revises the legal framework on Health and Safety conditions in the construction site (incorporating the minimum prescriptions required for temporary/mobile construction sites established by the Directive n.º 92/57/CEE of 24 June).

In the United Kingdom

Generally, the laws governing health and safety relate to all construction activities and trades (including design) and are not industry specific. There are several Acts and Regulations. Some of the principal Acts which deal with health, safety and welfare in construction are as follows:

- Health and Safety at Work etc. Act 1974
- Mines and Quarries Act 1954
- Factories Act 1961
- Offices, Shops and Railways Premises Act 1963
- Employers Liability Acts – various
- Control of Pollution Act 1989
- Highway Act 1980
- New Roads and Streetworks Act 1991
- Corporate Manslaughter and Corporate Homiside Act 2007

The fundamental Act governing health and safety in construction is the Health and safety at Work etc. Act 1974. The principal regulations of this Act which affect design and construction are:

- Management of Health and Safety at Work Regulations 1999 amended 2006
- Construction (Design and Management) Regulations 2007 (known as the CDM Regulations)
- The Work at Height Regulations 2005 amended 2007.

Some other related regulations and guides are:

- Site Waste Management Plans Regulations 2008
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995

- The Control of Major Accident Hazards Regulations 1999 (COMAH) amended 2005
- The Chemicals (Hazard Information and Packaging for Supply) Regulations 2003 (CHIP 3)
- The Health and Safety (Display Screen Equipment) Regulations 1992
- COSHH (Control of Substances Hazardous to Health) Regulations 2002: Provision and Use of Work Equipment Regulations (PUWER 98)
- Lifting Operations and Lifting Equipment Regulations (LOLER 98)
- Personal Protective Equipment at Work Regulations 1992
- Signposts to the Health and Safety (Safety, Signs and Signals) Regulations 1996
- Control of Asbestos Regulations 2006

Some of the principal Acts and Regulations which deal with environment, are as follows:

- The Environmental Protection Act 1990
- Environment Act 1995
- The Clean Air Act 1993
- Radioactive Substances Act 1993
- The Control of Asbestos Regulations 2006
- The Ionising Radiation Regulation 1999
- The Control of Lead at Work Regulations 2002

The regulatory organisations are (according to the Environment Act 1995):

- The Environment Agency (in England and Wales)
- The Scottish Environmental Protection Agency (in Scotland)

In Greece

Under Greek legislation all construction workers' professional activities are considered hazardous. Thus, the profession of the Concrete Builder is also considered hazardous. In Greece the Concrete Builder is the most important profession among the all professions because he is responsible for the strength of the building structure. He is also responsible for the scaffolding and platforms assembling and dismantling.

The major dangers are: Falls from height; dropped tools or materials; incorrect use of equipment; fire; scalds; forms and shuttering collapse

The legal framework for the Concrete Builder covers the following sections: rules of preparing and undertaking the job and Health and safety regulations

The regulations for the scaffolding assembling and use are:

- Presidential Decree 1073/81 art. 34,35,36
- Presidential Decree 778/80 art. 3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,20,21
- Presidential Decree 1073/81 art. 43,44
- Presidential Decree 22/29 -12-1933 as revised by P.D.. 17/7-1-78
- Presidential Decree 17/1978
- Ministers Ordinance 16440/F 10.4/445/1993

Works at height regulations are:

- Works at height without scaffolds: Presidential Decree 778/80 art. 17
- Works on scaffolds: Presidential Decree 778/80 art. 9, 11

The health and safety regulations can be categorized as following:

- General regulations for health and safety
- Working at height using scaffolding and mobile platforms
- Protection from electrical shock
- Environment protection

Legislation referred to health and safety regulations:

- Presidential Decree 22/12/33 (I.G.G 406 A΄) “On security of workers using ladders”
- Presidential Decree 778/80 (I.G.G 193 A΄) “On security measures during building construction”
- Presidential Decree 1073/81 (I.G.G. 260 A΄) “On security measures whilst performing tasks related to housebuilding and engineering works”
- Law 1396 (I.G.S 126 A΄) “Obligations of observance of security measures in structures”

- Law 1430/84 (I.G.G. 49 A΄) "Ratification of the 62 International Employment contract, "As regards the safety provisions in the construction industry and resolving directly related issues"

- Law 1568/85 (I.G.G. 177 A΄) "Health and safety of workers"

- Presidential Decree 71/88 (I.G.G. 32 A΄) "Regulation for fire protection of buildings"

- Ministry ordinance 9087 1004/96 (I.G.G 849 B΄) "Operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas"

- Presidential Decree 395/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use of work equipment by workers at work in compliance with directive 89/655 EU"

- Presidential Decree 396/94 (I.G.G 220 A΄) "Minimum safety and health requirements for the use by workers of personal protective equipment at work in compliance with the directive of the Council 89/656/EU"

- Presidential Decree 105/95 (I.G.G 67 A΄) "Minimum requirements for safety and health at work in compliance with directive 92/58/EU"

- Presidential Decree 16/96 (I.G.G 10 A΄) "Minimum safety and health in the workplace in compliance with directive 89/654/EU"

- Presidential Decree 17/96 (I.G.G 11 A΄) "Measures to improve safety and health of workers at work in compliance with the instructions 89/391/EU and 91/383/EU"

- Presidential Decree 305/96 (I.G.G 212 A΄) "Minimum safety and health requirements at temporary or mobile construction sites in compliance with directive 92/57/EU"

- Presidential Decree 62/98 (I.G.G 67 A΄) "Measures for the protection of young people at work, in compliance with directive 94/33/EK"

- Ministry ordinance 130646/84 (I.G.G 154 B΄) "Security measures calendar"

In Italy

In Italy, this profession does not exist and this work is usually performed by a qualified mason. Therefore, to become a mason, a carpenter or a plasterer one can attend specific training courses that lead to a qualification after compulsory education & training is completed (16 years old). The courses are organized by construction schools, which allow appropriate competencies and skills to enter the labour market.

The vocational training in the construction sector is managed by a national equal education system regulated by the Collective Labour Agreement (art. 90) for construction companies who are members of ANCE – the National Association Construction Builders and varuiys trade unions (FENEAL-UIL, FILCA-CISL, FILLEA-CGIL).

FORMEDIL is the national body for training construction workers and it promotes, manages, and coordinates training and refresher courses in the construction sector. These are organized by the construction schools located across the different Regions and Provinces.

An individual can choose to take up an apprenticeship in a company (which is different according to each profession) and then be hired. Alternatively, an individual can decide to establish his/her own company. According to the Act 443/85 regarding Crafts, if a person wants to establish a company, then he/she must comply with the information and requirements as set out in the act. In particular, the construction company can have a maximum of 10 employees and 5 apprentices. The number can be increased to 14 employees, but these additional workers must be apprentices.

The application should be submitted to the Provincial Register by the local Chamber of Commerce.

Important links:

- FORMEDIL: www.formedil.it
- ANCE – Associazione Nazionale Costruttori Edili: www.ance.it
- CEFME – Formazione, ricerca e servizi per l'industria delle costruzioni: www.cefme.it
- Chamber of Commerce: www.camcom.gov.it/

To find information regarding the legislation in the construction sector, you can visit the following websites:

- Ministry of Infrastructures and Transports: http://www.mit.gov.it/mit/site.php
- www.edilizia.com
- www.edilpro.it
- www.edilportale.com
- www.edilbox.it

Legislation on safety at work in the construction sector

The main legislation relating to safety at work is listed below. Several Regions have also issued regional acts.

- Decree President of the Republic No. 547 – 27/04/1955 “Legislation to prevent industrial accidents”
- Decree President of the Republic No. 164 – 07/01/1956 “Legislation to prevent industrial accidents in the construction sector”
- Decree President of the Republic No. 303 – 19/03/1956 “Hygiene at work”
- Legislative Decree No. 494 – 14/08/1996 “Implementation of Directive 92/58/CEE concerning minimum safety and health standards to be applied in the construction sites”
- Legislative Decree No. 277 – 15/08/1991 “Implementation of several EU Directives concerning protection of workers against the risks associated with exposure to chemical and physical agents”
- Legislative Decree No. 493 – 14/08/1996 “Implementation of Directive 92/58/CEE concerning the minimum standards for safety signs at work”
- Ministerial Decree 10/03/1998 “Safety criteria for fire prevention and emergencies at work”
- Legislative Decree No. 235 – 08/07/2003 “Implementation of Directive 2001/45/CE concerning minimum safety and health standards when using equipment at work”
- ISPESL guidelines to identify and use protection devices to prevent falls

Links:

- Ministry of Labour: www.lavoro.gov.it/
- Ministry of Infrastructures and Transports: http://www.mit.gov.it/mit/site.php
- ISPESL: www.ispesl.it

In Poland

Legal basis to be observed in order to perform the job in Poland:

- Act dated 07.07.1994 Building Act (Journal of Laws 2006 No. 156 item 1118 with subsequent amendments)
- Act dated 16.04.2004 on building products (Journal of Laws 2004 No. 92 item 881),
- Regulation of the Minister of Infrastructure dated 14.05.2004 on inspections of building products for sale (Journal of Laws 2004 No. 130 item 1387)

- Act dated 27.04.2001 Environment Protection Act (Journal of Laws 2006 No. 129 item 902 with subsequent amendments)

- Regulation of the Minister of Infrastructure dated 12.04.2002 on technical conditions for buildings and location of buildings (Journal of Laws 2002 No. item 690 with subsequent amendments),

- Regulation of the Minister of Economy and Labour dated 27.07.2004 on industrial safety (Journal of Laws 2004 No. 180 item 1860 with subsequent amendments)

- Act dated 30.10.2002 on social work accident and occupational diseases (Journal of Laws 2002 No. 199 item 1673 with subsequent amendments),

- Regulation of the Minister of Labour and Social Policy dated 26.09.1997 on general industrial safety regulations (Journal of Laws 2003 No. 169 item 1650 with subsequent amendments),

- Regulation of the Minister of Infrastructure dated 6.02.2003 on building work safety (Journal of Laws 2003 No. 47 item 401)

- Regulation of the Minister of Economy dated 30.10.2002 on minimum safety requirements for machinery use by employees (Journal of Laws 2002 No. 191 item 1596 with subsequent amendments),

- Act dated 24.08.1991 on fire protection (Journal of Laws 2002 No. 147 item 1229 with subsequent amendments)

In France

1- Basic concepts: standards, DTU, Technical advice (Avis Techniques).

1.1. Standards: see: Standards and European directives (source: AFNOR)

French approved standards are mandatory for State and local government funded contracts. They are also recommended for privately funded contracts.

1.2. **DTUs** (Unified Technical Documents) are documents that contain technical rules relating to the execution of building works using traditional techniques. They are recognized and approved by construction professionals. They also provide a reference point for insurance experts and the courts. Failure to comply with DTUs may lead to the invalidation of warranties offered by insurance providers. DTUs specify standards for traditional construction methods and are considered the epitome of reference texts. They are intended for relevant state bodies as well as contractors (whether architects or general contractors), owners and other experts. They are authored by a committee advising on technical texts.

1.3. **Technical advice** is advice from a committee of experts specialising in relevant trades and the expected behaviours of materials, components or processes. They define the characteristics of any materials, components or processes involved, and give advice on their durability and suitability for use and how they comply with regulations.

2 - DTU

2.1. Status of DTU

The DTUs are established by a body created in 1958, the "**Groupe de Coordination des Textes Techniques / Groupe DTU"** (the "Coordinating Group of Technical Texts or Group DTU").

In 1990, this group became the "**Commission Générale de Normalisation du Bâtiment/DTU** "(the General Committee for the Standardisation of Building / DTU) in order to integrate it into the French official system, which was necessary to comply with European technical harmonization (Eurocodes)

This means that the DTUs have become standards. The transformation took place gradually through the regulatory procedures that govern standardsation.

As a result, the DTU(s) now have one of the following statuses:

Approved French standard (**Norme française homologuée): **this is a standard which has received official government approval, its technical value is recognized, and it plays an important role in the construction system,

Experimental standard (Norme expérimentale): which is undergoes a period of probation before being confirmed or amended to become a certified French standard,

Documentation booklet (Fascicule de documentation) : standard documents, essentially informative documents,

DTU: the original form of the documents. Not part of the official standard system. In most cases DTU status is temporarily held in anticipation of its integration into the official standard system.

2.2. Private works

DTU is implemented following an agreement between the "maitre d'ouvrage" and the construction contractor. A DTU only commits the signatories, giving it a sense of obligation of contract.

Some standards and some French registered DTUs can be mandatorily enforced by regulatory decisions (often when safety-related).

2.3. Public works

The amended Decree of January 26, 1984 governs the application of French standards in contracts approved by the government, local authorities, public bodies etc., except in special cases as listed in the decree.

2.4. Composition of a DTU

A DTU may consist of the following documents:

Technical specification clauses booklet (**cahier des clauses techniques**: **CCT**) which sets out the requirements for the selection and use of materials,

Specification of special provisions booklet (**cahier des clauses spéciales**: **CCS**) which defines performance limits and obligations to other trades,

Rules for calculating the structural design.

All these documents are contractual documents and must be adhered to. There are also other documents, such as memos and selection guides, which are useful for structural designs that are not intended to be imposed by contract.

Like ISO standards, the DTU(s) must be bought. They can be found on the CSTB website: http://boutique.cstb.fr/

(CSTB = centre scientifique et technique du bâtiment: scientific and technical center for construction)

DTUs and other required documents are listed on the CSTB website. There are specific DTUs for each profession : (see example for roofers on the next page)

http://boutique.cstb.fr/dyn/cstb/Upload/Fichiers/Liste_0310.pdf

HEALTH AND SAFETY

On building sites required by the coordinator of safety to have a general plan of coordination, the companies involved must create a **PPSPS** (Particular plan of safety and protection of health) valid for **all workers** on the building-site

PPSPS: Particular plan of safety and protection of health

Contents of the PPSPS

1. The name and address of the company, the address of the building site, the name and qualifications of the person in charge of the work.

2. The description of work and methods of work showing the company's specific risks and chosen means of prevention, taking into account any environmental constraints. Work involving risks of interference arising from co-activity with other companies, mutual risks and the prevention methods available.

3. Procedures for observing any measures of general coordination defined by the coordinator.

4. Rules for hygiene and for workers' areas as laid out in the general coordination plan .

5. First aid organization of the company; including the medical equipment available, first-aiders and on site, measures for evacuating any injured persons, according to the general coordination plan.

The descriptive part of the plan is the most important; it must be accompanied by a detailed analysis of the risks related to procedures, materials, devices and installations, the use of dangerous substances or preparations, and to circulation on site.

Plans or sketches drawn for the building site can effectively replace text. Photocopies of documents are to be avoided in general , except for private copies.

The plan can evolve and change, so it is always possible to modify any of the given procedures or preventive measures if the incurred risks are decreased or if the preventive measures give an equivalent guarantee.

Texts referring to the **labor regulation:**

Principle of prevention articles R 230-1 with R 234-23,

General plan of coordination R 238-20 to R 238-36.

texts **for the prevention** **and the safety of the worker**s:

N° circular 6 DRT of April 18th, 2002 of the ministry for employment and solidarity,

Law N° 91-1414 of December 31st, 1991 published with the OJ N°5 of January 7th, 1992,

European directive 89/391/CEE of June 12th, 1989,

Decree 2001-1016 of November 5th, 2001 relating to the single document published in the 258 Olympics of the 11/7/01 page 17523.

Chapter III - A NEW CONTEXT

General

Chapter I briefly described the traditional context of the concrete builder and summarised the main activities and corresponding tasks of this important construction trade. Essentially, the concrete builder deals with scaffolding, reinforcement and concrete placement and assembly of pre-cast concrete elements. These generic activities currently encompass a set of tasks for which a substantial number of skills are required.

The concrete building trade has been evolving very sensitively since it was first introduced in the construction activity. It may no longer be considered a new trade (as concrete is now over 100 years old) but, in recent times, a new concrete building trade may be acknowledged. This is basically due to the conjugation of two strengths: **client demands and emerging technologies.**

The ever increasing client demands have been placing many important challenges to the construction industry, namely, stricter higher quality standards, lower costs, shorter production time, more respect for the environment and so forth. As for the **technological development,** it may be appraised through the introduction of new materials, new components and new construction processes. All in all, clients set stricter specifications for their projects because they are aware of new possible solutions and technologies that can respond more effectively to their needs.

Accordingly, new topics of concrete building need to be constantly added to training programmes in order to improve the professional skills of those working in construction. The content of this manual is a contribution for this. However, the diversity of topics would not make it feasible to deal with all of them in such a small volume. Additionally, the extent to which new topics deserve consideration depends on a set of factors for example, the student's background, their willing to learn, the cultural environment and so on. Chapter 4 will deal with the innovative aspects affecting this trade.

Chapter IV - DESCRIPTION OF NEW SOLUTION

General aspects

Concrete is traditionally reinforced with steel bars or tendons specifically located in the structure to bear tensile stresses and thus optimise performance. However, concrete can also be improved by varying its composition to attain the required strengthening properties. This is accomplished by varying the type and amount of cement (commonly Portland cement), coarse aggregate (usually gravel or crushed rock), fine aggregate (sand), as well as other cementitious materials (such as fly ash, slag cement, metakaolin, ground granulated blast furnace slag, silica fume), water and chemical admixtures (such as accelerators, retarders, plasticisers or superplasticisers, water reducing admixtures, air-entraining admixtures).

Currently, there is a wide variety of alternative concrete depending on the need for upgrading to meet rigorous design requirements and consequently the intended application. These include for instance High Strength Concrete (HSC), High or Ultra High Performance Concrete (HPC or UHCP); Self Compacting Concrete (SCC); Engineered Cementitious Composite (ECC), also called bendable concrete; foamed concrete; high workability concrete; lightweight concrete; no-fines concrete; pumped concrete; sprayed concrete (shotcrete); waterproof concrete; autoclaved aerated concrete, and so on.

Concrete can also be reinforced by incorporating discontinuous fibres directly into the traditional hydraulic cement concrete mix consists essentially of cementitious material[4], aggregates (coarse and fine) and water and/or chemical admixtures) thereby producing Fibre Reinforced Concrete (FRC). Fibres may be made of steel, glass, synthetic materials (polypropylene, polyethylene, polyester, amarid, carbon) and natural (wood cellulose, sisal, bamboo, etc.). The inclusion of two or more fibre types in the same concrete mix is known as Hybrid Fibre Reinforced Concrete (HFRC). Section 4.1 will deal with this technology in more detail.

Another technology that has emerged as an alternative to traditional materials and techniques is an advance composite material made of fibres in a polymeric resin, also known as Externally Bonded Reinforcements with Fibre-Reinforced Polymer (EB-FRP). FRP materials composites offer unique properties in terms of strength, lightness, chemical resistance, non-corrosiveness and ease of application. These materials are readily available in several forms ranging from factory made laminates to dry fibre sheets that can be wrapped to conform to the geometry of a structures prior to adding the polymer resin. The relatively thin profile is often desirable in applications where aesthetics is a concern (RIZKALLA, 2000).

[4] Portland cement and supplementary cementitious materials such as fly ash and ground granulated blast furnace slag

FRP systems are gaining popularity due to their wide range of applications like strengthening, rehabilitation and retrofitting of reinforced concrete structures and structural elements (various types of structural elements, e.g., beams, slabs, columns, etc.). Despite the fibres and resins used in FRP systems are relatively expensive compared to traditional strengthening materials (like concrete and steel), the labour, equipment and building costs of installing FRP systems are often very low. Composites for structural strengthening are available today in the form of pre-cured strips (pre-cured shells to strengthen columns are also available) or uncured sheets. Pre-cured strips made of continuous unidirectional fibres (carbon, glass, aramid, etc) are embedded in a resin matrix (that works like the glue that allows the fibres to work together as a single element. Resins used are thermoset (polyester, vinyl ester, etc.) or thermoplastic (nylon, polyethylene terephthalate, etc.). Uncured sheets are made of unidirectional or bi-directional fibres (often called fabrics, in the latter case) that are either pre-impregnated or in situ impregnated with resin, and are highly conformable to the surface onto which they are bonded. Bonding is typically achieved with high-performance epoxy adhesives (Figure 1).

There are a number of special techniques related to the application of composites as externally bonded reinforcement worthwhile mentioning include [BAKIS, 2002]:

- **Pre-stressed strips:** Pre-stressing of composite strips prior to the bonding procedure results in a more economical use of materials but requires special clamping devices.

- **Automated wrapping and curing:** Wrapping of columns or other vertical elements such as chimneys, with flexible FRP sheets using automated machinery. The machinery can also apply heat and vacuum to assist curing.

- **Fusion-bonded pin-loaded straps:** A number of non-laminated thermoplastic FRP layers that may move relative to each other when loaded are applied in a single, continuous, thin tape that is fusion-bonded (welded) to itself for anchorage.

- **Placement inside slits**: FRP strips or even rods may be bonded into slits which are cut into the concrete or into masonry mortar joints.

- **Prefabricated shapes:** Prefabricated angles or shells may be externally bonded to structures.

- **Mechanically fastened FRP strips:** Specially designed FRP strips can be rapidly attached to concrete beams for flexural strengthening using powder-actuated fasteners.

Figure 1: Application of carbon strips to concrete structures [COBRAE, 2010, CLARK, 2008]

Finally, traditional steel bars can be replaced with bars or tendons made of composite materials (carbon, glass or other types of synthetic fibres) combined with other materials in order to achieve improved features such as: non-corrosive, non-conductive, high strength-to-weight ratio, lightweight, magnetic transparency, excellent fatigue resistance amongst other benefits. Composite fibre-reinforced polymer (FRP) bars are pultruded bars consisting of a multitude of unidirectional stretched fibres bonded with a production process that guarantees the complete impregnation of the fibres in an epoxy resin matrix. An example of the pultrusion process using glass fibres is shown in Figure 2. These composite rebars can be used in various structural elements such as concrete beams, columns, slabs and walls (Figure 3).

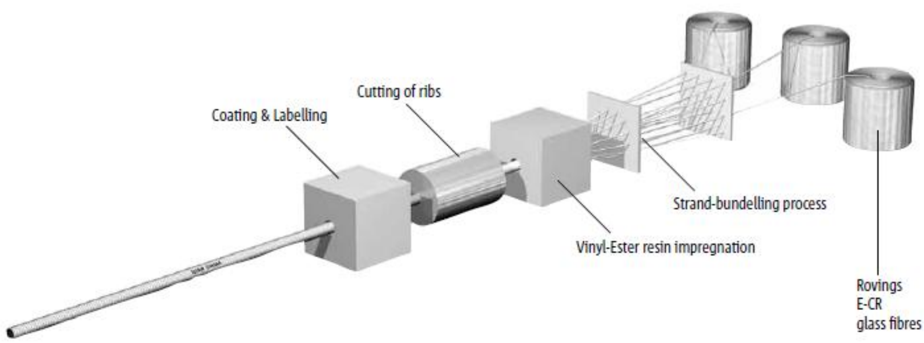

Figure 2: Pultrusion process [SCHOCK, 2010]

Figure 3: Composite rebar used in concrete slab [COBRAE, 2010]

All these technologies are not completely new. However, thanks to rigorous design requirements, durability and cost demands and optimised production processes, the range of applications in building and civil engineering is growing and becoming more common practice. While the new types of concrete and composite bars are produced at industrial level, FRC can be managed on site by workers. Hence, this technology will be covered in the following chapters especially Steel Fibre Reinforcement Concrete.

Fibre Reinforced Concrete

Although Fibre Reinforced Concrete (FRC) is considered an emerging material that can be easily handled by concrete workers, it has been in use for a few decades now. As previously mentioned, steel, glass, synthetic and natural fibres (see Figure 4) are the most commonly used fibres in FRC [ACI, 2002]:

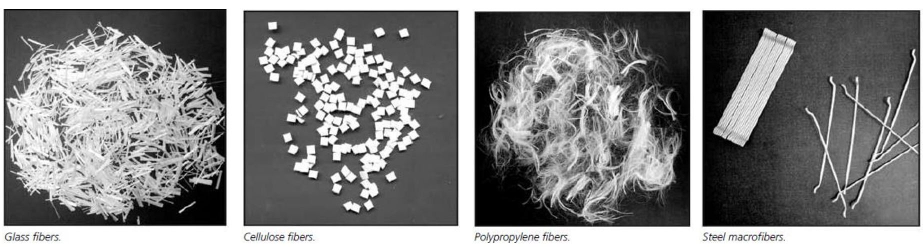

Figure 4: Examples of glass, cellulose, polypropylene and steel fibres [OLIVEIRA, 2010].

a) **Steel Fibre Reinforced Concrete (SFRC):** SFRC is made of traditional hydraulic cement concrete with steel fibres. Steel fibres are short, discrete lengths of steel with an aspect ratio from about 20 to 100, several possible cross-sections and sufficiently small to be randomly dispersed in an unhardened concrete mixture by using typical mixing procedures. ASTM A820 provides a classification for four general types of steel fibres based upon the product used in their manufacture: Cold-drawn wire (Type I), Cut sheet (Type II), Melt-extracted (Type III), other fibres (Type IV). Different applications require different fibre compositions. The composition of steel fibres generally includes carbon steel (or low carbon steel, sometimes with alloying constituents), or stainless steel. SFRC can be applied namely for:

- Cast-in-place concrete, e.g., tunnels, highway and airport pavements, industrial floors, repairs and new construction on major dams and other hydraulic structures, repairs and rehabilitation of marine structures such as concrete piling and caissons;

- Pre-cast and pre-compressed concrete, e.g., utility boxes and septic tanks;

- Shotcrete, e.g., repair and reinforcing of lighthouses, bridge piers, slope stabilization, tunnelling, roof support in mines;

- Slurry Infiltrated Fibre Concrete (SIFCON), e.g., impact and blast resistant structures, refractories, pavement repairs. This technology will be further discussed in section 4.2.

b) **Glass Fibre Reinforced Concrete (GFRC):** GFRC is composed of alkali resistant glass fibre, Portland cement, silica sand, water and additives. Production methods are either the spray-up process or the premix process.

   - *The spray-up process* (manual or automated) consists of simultaneously pre-mixing chopped glass fibres into a cement/sand slurry that is then deposited from a spray gun onto a mould surface producing relatively thin panels ranging from 12 to 20 mm. Each complete pass of the spray gun deposits layers of approximately 4 to 6 mm thick (e.g. a 13 mm thick panel would require two to three passes). The wet composite is roller compacted after each pass to ensure that the panel surface will conform to the mold face, remove entrapped air and to aid the coating of glass fibres by the cement paste. Composites are then moist cured (a minimum of seven days moist curing is recommended).

   - *The premix process* consists of mixing cement, sand, chopped glass fibre, water, and admixtures together into a mortar, using standard mixers, and casting with vibration, press-moulding, extruding, or slip-forming the mortar into a product. Mixing must be closely controlled to minimise damage to the fibre. Water-reducers are commonly used to facilitate fibre addition while keeping the water-cement ratio to a minimum. Since premix composites generally have only 2 to 3% by weight of Alkali resistant-glass fibre, they are not as strong as sprayed-up GFRC (4 to 6% by weight). GFRC applications include: architectural cladding, asbestos replacement, general building (tiles, shingles, lintels, hollow non-structural columns or pillars, impact resistant industrial floors, brick facade siding panels, cellular concrete slabs), etc.

c) **Synthetic Fibre Reinforced Concrete (SNFRC):** SNFRC are produced with synthetic fibres, namely acrylic, aramid, carbon, nylon, polyester, polyethylene, polypropylene and others. Synthetic fibres are added to the wet mix directly from bags, boxes, or feeders. Mechanical agitation during the mixing process is required to encourage the break-up of fibre bundles and their dispersion through the mixture. Placement techniques include all the standard methods such as batch casting, pumping, wet-mix shotcreting, and plastering. The use of dry-mix shotcrete for

SNFRC is difficult due to the propensity for the relatively low density fibres to be blown out either by the shotcrete nozzle air pressure stream or by environmental air streams. Applications include: cast-in-place concrete (such as slabs-on-grade, pavements, and tunnel linings) and factory manufactured products (such as cladding panels, siding, shingles, and vaults), shotcrete for slope stabilization and pool construction and mortar applications involving sprayed and plastered Portland cement stucco.

d) Natural fibre reinforced concretes (NFRC): NFRC are made of hydraulic cement concrete with discrete, distinct, discontinuous natural fibres such as coconut, sisal, sugar cane bagasse, bamboo, jute, flax, elephant grass, water reed, plantain, musamba, wood fibre (kraft pulp). These fibres do not have as high a flexural strength as glass or steel but they do provide good ductility. These type of concretes require special mix proportioning considerations to counteract the retardation effects of the glucose in the fibres. Natural fibres used for FRC can be classified as unprocessed natural fibres (UNF) or processed natural fibres (PNF). UNF are natural reinforcing materials obtained at low levels of cost and energy, using locally available manpower and technical know-how. These types of fibres are used in the manufacture of low fibre content FRC and occasionally have been used in the manufacture of thin sheet high fibre content FRC. PNF are those natural fibres that have been processed to enhance their properties. These fibres are derived from wood by chemical processes such as the kraft process. Kraft pulp fibres are used in sophisticated manufacturing processes, such as the Hatschek process, to produce thin sheet high fibre content FRC. Sisal fibre reinforced concrete can be used for (roof tiles, corrugated sheets, pipes, silos, gas and water tanks, other. Elephant grass fibre reinforced mortar and cement sheets has been used for low-cost house construction. Kraft pulp fibre reinforced cement has been used for flat and corrugated sheet, non-pressure pipes, cable pit, and outdoor fibre reinforced cement paste or mortar products for gardening).

The type of fibre used affects all the aspects of FRC production (i.e. the proportions of traditional concrete ingredients and the type and quantity of additives) and performance due to several key parameters, namely [HERNANDEZ, 2004]:

a) Length and aspect ratio (i.e. the ratio of length to the diameter of the fibres): Relatively short fibres may not effectively span over microcracks/cracks due to the insufficient bond length, thus resulting in poor enhancement to the structural ductility and durability. Conversely, longer fibres, which are more resistant to pull-out from the matrix, may raise the problem of balling during mixing. Aspect ratios are typically in the range 20-100, with an optimal value usually around 60 (fibre length and diameter below 75 mm and 1 mm, respectively);

b) Distribution: a uniform distribution of fibres throughout the matrix prevents the formation of zones that exhibit local cracks. This points out the critical importance of a proper fibre volume content, typically limited to the range 0.5-2% in case of batch casting to avoid balling, as well as of a correct production process. Moreover, a uniform dispersion of fibres provides isotropic strength properties not offered by conventional reinforced concrete.

c) **Interfacial bond** (i.e. the ability of the fibre to form a strong and durable bond with the surrounding concrete, at both the chemical and mechanical levels): Adequate shape and geometry of the fibres may clearly enhance this ability.

d) **Stiffness:** higher elastic moduli of the fibres result in improved load transfer capacity and crack bridging, thus providing the sought increase in concrete toughness and ductile structural response (fibres, although stiff, do not contribute in changing the pre-cracking properties of the concrete, for instance enhancing the strength, nor compensate for improper mix design and casting).

Some of the greatest benefits of FRC technology include improved durability, long-term serviceability, crack control and substantial matrix tensile strength (the latter by using high volume percentages of fibres, 5 to 10 percent or higher with special production techniques [302]). The key property of FRC is the improved toughness, i.e. the ability of the material to absorb energy and to exhibit a ductile behaviour. This is an advantage in terms of safety when dealing with civil structures, in particular in seismic regions. FRC improves the serviceability and durability levels of concrete structures (Figure 5) by preventing the occurrence of large cracks and consequently reducing the risks of corrosion of internal reinforcement and concrete deterioration.

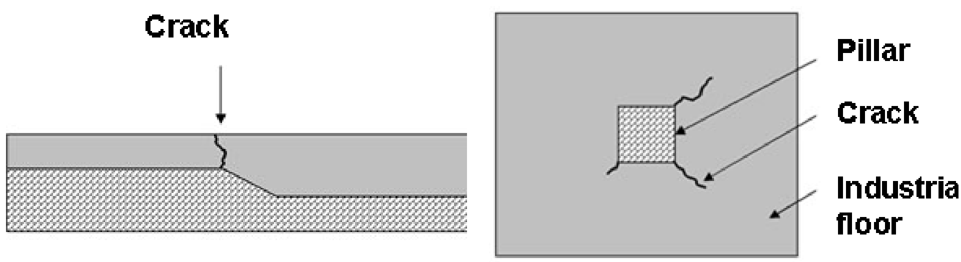

Figure 5: Examples of cracks shrinkage or variation of slab thickness

The presence of fibres modifies the cracking behaviour resulting from tensile stresses. In other words, once fibre reinforced concrete has reached its maximum strain and cracking has occurred, the fibres bridge the crack edges enhancing the residual strength (see Figure 6).

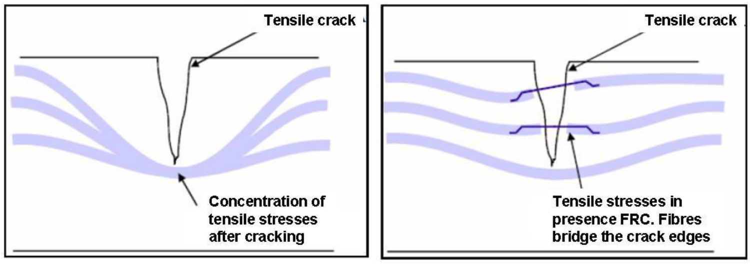

Figure 6: (a) tensile crack in "traditional" concrete without fibres, (b) tensile crack in FRC with fibres bridging the crack edges (adapted from [GROSSI, 2006].

FRC can be an economical construction material due to the durability benefits and to reduced execution / labour costs. However, the economical aspects always need to be evaluated to avoid the use of a more costly material when conventional reinforcement, better matrix and/or more careful construction process may be sufficient.

Technological aspects of Steel Fibre Reinforced Concrete (SFRC)

The tasks required for producing SFRC are identical to those described in section 1.2 for ordinary concrete, with the exception that fibres that are an additional component that must be added to the concrete mix. The main features of producing SFRC are described under the following headings (adapted from [ACI, 2002]):

- **Composition:** SFRC is merely a product resulting from adding discontinuous discrete steel reinforcement fibres into a standard concrete mix (cement, aggregates, water and additives). Obviously, the components of the design mix need to be altered due to the additional fibres. This mixture must be carefully controlled to avoid problems such as segregation, agglomeration and a uniform distribution assured. As with conventional concrete, SFRC mixtures employ a variety of mixture proportions and use other cementitious materials and chemical admixtures depending upon the end use.

- **Fibre storage:** The steel fibres are usually delivered in big bags or boxes and should be stored in chronological order of delivery. Care should be taken to see that steel fibres are stored in a manner that will prevent their deterioration or the intrusion of moisture or foreign matter that might lead to rust and agglomerates of fibres difficult to disentangle. If fibres deteriorate or become contaminated, they should not be used.

- **Preliminary tasks:** These are identical to those for conventional concrete.

- **Production methods**

    - Requirements:

        - Approved mixing, placing, finishing, and quality control procedures must be followed.

        - SFRC delivered to the construction site must conform to applicable standards and regulations.

        - Tightly bound fibre clumps must be broken up before entering the mix.

        - The efficiency of the method of introducing the steel fibres into the mixture must be proven in the field during a trial mix.

        - Fibres must be dispersed uniformly throughout the mixture during the batching and mixing phase.

    - Mixing sequence: Fibres may be incorporated either by adding them into the batched mixture or by adding them with the aggregates at the batching plant In both cases, the water/cement ratio must be specified and the workability must be tested and compared to specifications.

        - Add the fibres to the concrete mixer (Figure 7 and 8) or truck mixer after all other ingredients, including the water, have been added and mixed. Steel fibres should be added to the mixer hopper at the rate of about 45 kg per minute, with the mixer rotating at full speed. The fibres should be added in a clump-free state so that the mixer blades can carry the fibres into the mixer. The mixer should then be slowed to the recommended mixing speed and mixed for 40 to 50 revolutions. Steel fibres may have been added manually by emptying the containers into the truck hopper, or via a conveyor belt or blower as shown in. Using this method, steel fibres can be added at the batch plant or on the job site. The workability of the mix must be specified before and after the incorporation of fibres in the mixture.

Figure 7: Manual addition in the truck mixture.

Figure 8: Mechanical addition in the truck mixture.

- Add the fibres to the aggregate stream in the batch plant before the aggregate is added to the mixer (Figure 9). Steel fibres can be added manually on top of the aggregates on the charging conveyor belt, or via another conveyor emptying onto the charging belt (Figure 10). The fibres should be spread out along the conveyor belt to prevent clumping.

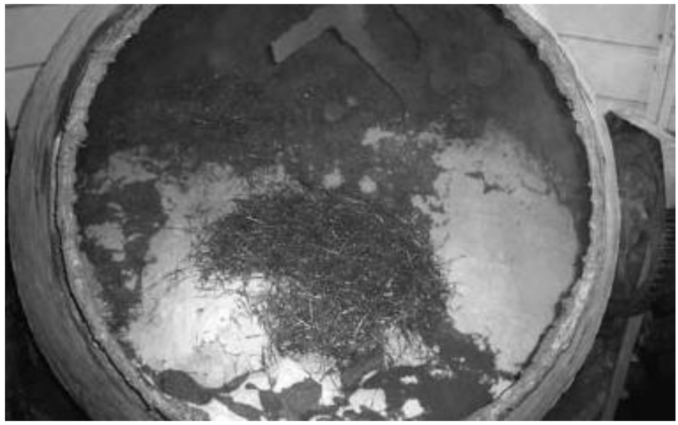

Figure 9: Manual insertion in the concrete mixer

Figure 9: Manual insertion with the aggregates in the belt conveyor

- Add the fibres on top of the aggregates after they are weighed in the batcher. The normal flow of the aggregates out of the weigh batcher will distribute the fibres throughout the aggregates. Steel fibres can be added manually or via a conveyor, like above.

- **Plant and tools:** Workers must use the same plant and tools as in conventional concrete for mixing, pouring, levelling and finishing

- **Safety:** Safety equipments are identical to those required for conventional concrete works

- **Workability:** Despite the performance gains conferred by fibres, their integration in the concrete mixture change the workability condition, especially if high quantities of fibres are used. The shape of fibres may also play a role because the higher the fibre slenderness, the lower the workability of the mixture. The workability of SRFC must be evaluated by testing procedures that are identical to those used for conventional concrete (e.g., the slump test).

- **Testing:** Testing procedures are identical to those used for conventional concrete (e.g. slump test and inverted slump test, see figures 11 to 13).

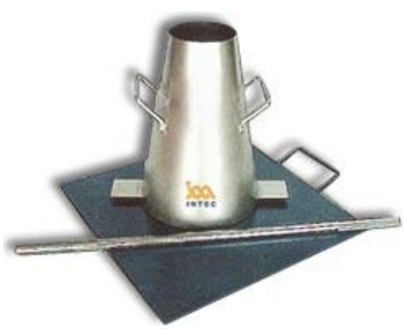

Figure 4: Slump test device

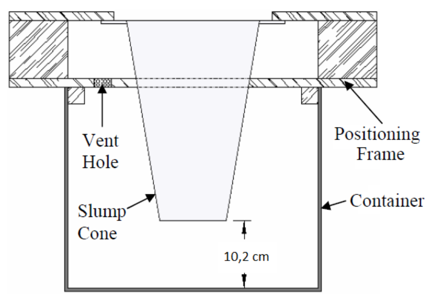

Figure 5: Inverted Slump Test

[OLIVEIRA, 2010]

- **Concrete casting:** Identical to conventional concrete.

- **Concrete levelling and finishing:** Identical to conventional concrete.

Chapter V – TRAINING PART

Participants will have a three day course divided into theoretical (1 day) and practical training (2 days). The first day will cover the theoretical concepts of Fibre Reinforced Concrete. The following two days will be used by the participants to apply the knowledge gained in the theoretical session. The acquisition of new competences will be evaluated by means of a test delivered to the participants at the end of the training.

Theoretical training

Participants will be provided with all relevant information regarding emerging trends and innovations in concrete, with particular reference to Fibre Reinforced Concrete (FRC). The following subjects will be covered:

- New context in concrete construction.
- Emerging trends in concrete reinforcement.
- Fibre Reinforced Concrete (FRC), types and applications.
- Mixture proportioning of Steel Fibre Reinforced Concrete (SFRC).
- Placing, finishing, curing and protecting FRC.
- Methods and tools for applying steel fibres.
- Workplace organization, health and safety, environmental and quality concerns.

Practical training (2 days)

1st Day

- Indentifying different types of fibres for concrete reinforcement
    - Steel fibres
    - Glass fibres
    - Synthethic fibres
    - Natural fibres
- Handling steel fibres and preparing them for mixing

2nd Day

- Adding fibres to the concrete mix
- Adding fibres to the aggregates
- Testing concrete before and after adding fibres

A summary of the workshop, a list of FAQs, remarks and conclusions will be provided at the end of the training sessions.

Test part:

	Question	**Yes**	**No**
1	Fibres are an alternative reinforcement method to traditional rebar reinforcement.		
2	Fibre reinforcement is basically using fibre made reinforcement bars in the place of traditional steel bars.		
3	Mixing fibres in concrete avoids the need for any other type of reinforcement.		
4	The same type of concrete composition is appropriate for fibre reinforcement concrete.		
5	The use of fibres in concrete elements is limited to incorporating them in the concrete mixture.		
6	Fibres are not useful for repairing concrete because they must be incorporated in the concrete mix.		
7	External reinforcement is possible in concrete but fibres cannot be used for that purpose. Beyond steel bars, special strips made of other extremely resistant materials are also available in the market for that, nowadays.		
8	There are many types of fibres that can be used for concrete reinforcement but steel fibres are structurally safer than other types thus they are preferred.		
9	There is no need for design when it comes to fibre reinforced concrete because the operator just has to incorporate a specified quantity of them in the mixture.		
10	Fibre reinforced concrete is not as safe as the steel rebar reinforced concrete therefore a special permission is required to use it on site and special health and safety conditions must be met by operators.		

	Question	Yes	No
11	The pressure of concrete on the formwork significantly increases in the case of fibre reinforced concrete therefore extra resistance must be met by scaffolds.		
12	Steel fibres for concrete reinforcement from distinct suppliers are very similar in shape, length and section. The distinction is just given by the type of steel they are made of.		
13	Cracking is more frequent when fibre reinforced concrete is used because an additional material is added to the traditional mixture.		
14	There is just one way of incorporating steel fibres in the concrete mixture: By adding them in the concrete mixer or truck.		
15	Workability is a big problem when steel fibre reinforcement is used because the concrete mass hardens much quicker than ordinary concrete		
16	Special systems have to be used to control workability for steel fibre concrete because the presence of fibres prevents the use of common tools.		
17	Steel fibres are usable for producing most concrete elements (slabs, beams, columns, and so on) whereas other types of fibres are only applicable to lighter elements (like prefabricated units) and finishings		
18	The ratio water cement changes when fibres are incorporated in the mixture.		
19	Ordinary vibrators can be used for fibre reinforced concrete		
20	Curing must be more careful with SFRC, because the fibres cause the concrete surface to heat more in hot days.		

USEFUL RESOURCES:

Concrete related construction products

BETECNA: http://www.betecna.pt/

BEKAERT http://www.bekaert.com

BIU: http://www.biu.pt/products

PGIFIBRES: http://www.pgifibres.com/

FORTIUS: http://www.fortius.be

CIMPOR: http://www.cimpor.pt/

SECIL: http://www.secil.pt/

APEB, Associação portuguesa de Empresas de Betão Pronto: http://www.apeb.pt/

International Standards

ACI, American Concrete Institute: http://www.concrete.org

ASTM, International Standards: http://www.astm.org

List of references of harmonised standards: http://ec.europa.eu/enterprise/policies/european-tandards/documents/harmonised-standards-legislation/list-references/construction-products/index_en.htm

Associations / Institutes

ACI - American Concrete Institute: http://www.concrete.org/general/home.asp

Business Association of Portugal (*AEP, Associação Empresarial de Portugal*): http://www.aeportugal.pt

Civil Construction and Public Works Industry Association (*AICCOPN, Associação dos Industriais da Construção Civil e Obras Públicas*): http://www.aiccopn.pt/

Construction and Public Work Companies Association (*AECOPS, Associação de Empresas de Construção e Obras Públicas*): http://www.aecops.pt

Construction and Real Estate Institute (*INCI, Instituto da Construção e do Imobiliário, I.P.*): http://www.inci.pt

FBI - Federation Internationale du Beton: http://www.fib-international.org/

FIB - International Federation for Structural Concrete: http://www.fib-international.org/

Institute to Support Small and Medium-Sized Enterprises and Innovation (*IAPMEI, Instituto de Apoio às Pequenas e Médias Empresas e à Inovação*): http://www.iapmei.pt

Minister for Public Works, Transport and Communications (*MOPTC, Ministério das Obras Públicas Transportes e Comunicações*): http://www.moptc.pt

National Laboratory OF Civil Engineering (*LNEC, Laboratório Nacional de Engenhaia Civil*): http://www.lnec.pt/

Public Works Contractors Association (*ANEOP, Associação Nacional de Empreiteiros de Obras Públicas*): http://www.aneop.pt

Portuguese Centres providing training for the construction sector

Institute for Employment and Vocational Training (*IEFP, Instituto de Emprego e Formação Profissional*): http://portal.iefp.pt

Professional Training Center of the Civil Construction and Public Works Industry in the North (*CICCOPN, Centro de formação Profissional da Indústria da Construção Civil e Obras Publicas do Norte*): http://www.ciccopn.pt/

Professional Training Center of the Civil Construction and Public Works Industry oin the South (*CENFIC, Centro de formação Profissional da Indústria da Construção Civil e Obras Publicas do Sul*): http://www.cenfic.pt/

Construction and Public Work Companies Association (*AECOPS, Associação de Empresas de Construção e Obras Públicas):* http://www.aecops.pt/

Vocational Training in Portugal

Institute for Employment and Vocational Training (*IEFP, Instituto de Emprego e Formação Profissional*): http://portal.iefp.pt

National Agency for Qualification (*ANQ, Agência Nacional para a Qualificação, I.P.*): http://www.anq.gov.pt

Employment and Vocational Training Observatory (*OEFP, Observatório do Emprego e Formação Profissional*): http://oefp.iefp.pt

Labour in Portugal

Ministry for Labour and Social Solidarity: http://www.gep.mtss.gov.pt/edicoes/bte/

Law n. 7/2009 of 12th February approves the new Labour Code in Portugal. Accessed 28th January 2010 at Diário da República Electrónico: http://dre.pt/pdf1sdip/2009/02/03000/0092601029.pdf

Collective Work Contracts in the Construction Sector (CCT, Contratos Colectivos de Trabalho para o Sector da Construção). Accessed 28th January 2010 at INCI:

http://www.inci.pt/Portugues/Construcao/EmDestaque/Documents/bte12_2009.pdf or http://www.aecops.pt/Downloads/tabid/107/language/pt-PT/Default.aspx

and list of documents:

http://www.inci.pt/PORTUGUES/CONSTRUCAO/EMDESTAQUE/Paginas/ContratosColectivosTrabalhoSectorConstrucao.aspx

Directorate-General for Employment and Work Relations. Ministry for Labour and Social Solidarity (DGERT, Direcção-Geral do Emprego e das Relações de Trabalho, Ministério do Trabalho e da Solidariedade Social):

Cabinet for Strategy and Planning Ministry for Labour and Social Solidarity (GEP, Gabinete de Estratégia e Planeamento, Ministério do Trabalho e da Solidariedade Social): http://www.gep.mtss.gov.pt

Vocational Training in the EU

European Centre for the Development of Vocational Training (CEDEFOP): http://www.cedefop.europa.eu

European Credit system for Vocational Education and Training (ECVET): http://ec.europa.eu/education/lifelong-learning-policy/doc50_en.htm

European Network of Reference and Expertise in VET (ReferNet): http://www2.cedefop.europa.eu/etv/Projects_ Networks/Refernet/default.asp

European Network for Quality Assurance in Vocational Education and Training (ENQAVET): ttp://www.enqavet.eu/

European Training Foundation (ETF): http://www.etf.europa.eu

Portal on Learning Opportunities throughout the European Space (PLOTEUS): http://ec.europa.eu/ploteus/

REFERENCES:

ACI (2002) State-of-the-Art Report on Fibre Reinforced Concrete (ACI 544.1R-96) reported by ACI Committee 544 (re-approved 2002).

CLARK, D. (2008) From Eyesore to Opportunity: Adapting an Older Building for a New Use. Accessed 3rd July, 2010 at: http://www.buildings.com/ArticleDetails/tabid/3321/ArticleID /5837/Default.aspx

COBRAE: Accessed 3rd July 2010 at: http://www.cobrae.org/htmlfolder/standaard.html

GROSSI, B. F. (2006) Uma contribuição para a modelagem numérica do concreto com fibras curtas de aço. Tese apresentada ao curso de Pós-Graduação em Engenharia de Estruturas, Belo Horizonte. Accessed on the 3th July 2010 at: http://www.pos.dees.ufmg.br/teses/7.pdf

HERNANDEZ, E.S, MASETTI, F., MATTA, F. and SCOTT, A. (2004): Fibre Reinforced Concrete in Structural Engineering: a brief overview CE 301- Structural Engineering with Emerging Materials, term paper.

OLIVEIRA, M. A. G. de (2010) Betão Reforçado com Fibras, Master Thesis, University of Minho, 2010.

RIZKALLA, S. H. And SOUDKI, K.A. (2000) Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures, Reported by ACI Committee 440.

SCHOCK (2010): Technical Information. Accessed 4th July at: http://www.schoeck-combar.com

FURTHER READING AND SITES:

ACI (2009): The Contractor's Guide to Quality Concrete Construction. American Concrete Institute. 3rd Edition. ISBN 0-87031-167-0.

ASTM A820-06 Standard Specfication for fibres in Fibre Reinforced Concrete

ASTM C1018-07 Standard test methods for flexural toughness & first crack strength

AU YONG THEAN SENG. High Performance Concrete: http://www.scribd.pdf

BAKIS, C. E. *et al* (2002) Fibre-Reinforced Polymer Composites for Construction—State-of-the-Art Review. Journal of Composites for Construction. Accessed on the 3rd July 2010 at: http://www.engr.wisc.edu/cee/faculty/bank_lawrence/BakisBanketalJCC150thpaper.pdf

BALAGURU, P.N. and SHAH, S.P. (1992): Fibre Reinforced Cement Composites, McGraw-Hill, 530 pp.

CHUNG, N. Y.L. Fibre Reinforced Polymer (FRP) Composites: The Evolution of Composites within Civil Engineering: http://gnatchung.tripod.com/FRP

COUTTS, R.S.P. and RIDIKOS, V. (1982), Refined Wood Fibre-Cement Products, Australian and New Zealand Pulp and Paper Industry Journal, 35[5], pp. 395-400.

EN 14889-1:2006 Fibres for Concrete. Steel Fibres. Definitions, specifications & conformity

EN 14889-2:2006 Fibres for Concrete. Polymer Fibres. Definitions, specifications & conformity

EN 14845-1:2007 Test methods for fibres in concrete

FISHER, G. and LI, V.C. (2001) Intrinsic Response Control of Moment-Resisting Frames Utilizing Advanced Composite Materials and Structural Elements", ACI Structural Journal, 100[2], pp. 166-176.

FORSTER W. F. STEPHEN, High-Performance Concrete-Stretching the Paradigm", Concrete International, Vol. 16, No. 10, October 1994, pp. 33-34.

FORTIUS, BK International, Belgium: http://www.fortius.be

GEOPOLYMER:

http://www.geopolymer.org/news/ research-report-on-fly-ash-based-geopolymer-concrete

GROSSI, B. F. (2006): Uma contribuição para a modelagem numérica do concreto com fibras curtas de aço. Tese apresentada ao curso de Pós-Graduação em Engenharia de Estruturas, Belo Horizonte: http://www.pos.dees.ufmg.br/teses/7.pdf

MINDNESS, S. (1995) Fibre Reinforced Concrete: Challenges and Prospects, Fibre Reinforced Concrete – Modern Developments, Proceedings of the First University-Industry Workshop on Fibre Reinforced Concrete, Eds. N. Banthia and S. Mindness, pp. 1-11.

NEMATI, K. M. (2007): Fibre Reinforced Concrete (FRC). Concrete Technology CM 425, Unviversity of Washington: http://www.toodoc.com

NRMCA. National Ready Mixed Concrete Association:

http://www.nrmca.org/aboutconcrete/cips/14p.pdf

OSHA. Construction Industry Digest. Accessed 20th October 2009 at Occupational Safety and Health Administration: http://www.osha.gov/Publications/osha2202.pdf

PGIFIBRES: http://www.pgifibres.com

ROMUALDI, J.P. and BATSON G.B. (1963) Mechanics of Crack Arrest in Concrete, ASCE Journal of Engineering Mechanics Division, 89[EM3], pp. 147-168.

SAKAI, K., OCHI, T. and KITOH, M. (1995) Applications of Steel Fibre Reinforced Concrete in Japan, Fibre Reinforced Concrete – Modern Developments, Proceedings of the First University-Industry Workshop on Fibre Reinforced Concrete, Eds. N. Banthia and S. Mindness, pp. 51-62.

SCHRADER, E.K. (1986) Fibre Reinforced Concrete Pavements and Slabs - A State-of-the-Art Report, Steel Fibre Concrete, Elsevier, pp. 109-131.

SIRIUSLINK: http://www.siriuslink.com/client/kuraray/pvaf/online/

TOOLBASE: Concrete Aggregate substitutes.

http://www.toolbase.org/Technology-Inventory/Foundations/concrete-aggregate-substitutes