Reinforcing and strengthening of structures with FRP reinforcement

Theory / Design / Lab experience

INFORMATION PACKAGE
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23-27 January 2017 — Ghent University
Scientific coordination

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www.frpcourse.eu
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About the FRP Course

Offering high strength, light weight and excellent durability characteristics, in combination with ease of application, FRP (Fibre Reinforced Polymer) reinforcement has become a technique of increased popularity in the construction sector. Since the early 1990’s commercial applications of strengthening with bonded FRP reinforcement and of FRP reinforced and prestressed concrete structures have been growing numerously. With a share of 17%, composites in construction have become one of the main sectors in the global composites market. Furthermore, FRP as non-traditional reinforcement has reached a broad status of recognition in the previous years and is entering mainstream design codes, such as fib Model Code 2010.

“This course gives an excellent exposure on the design and application of FRP reinforcement in new construction and rehabilitation and is taught by international experts in this field. The aim of the course is to train participants with specific knowledge and skills, allowing them to consider, design and apply FRP reinforcement in a systematic way”

This training course is intended for all industry and research professionals involved in FRP reinforcement for reinforcing concrete structures or for strengthening of existing structures.

- Engineers and designers in the public or private sector, involved in the design of concrete structures and/or the design of repair and strengthening (including seismic rehabilitation) of existing structures.
- Engineers at construction companies, material suppliers or research institutes with special interest into sustainable construction.
- Technical advisors of construction companies and control organisms.
- Professionals interested in the field of developing and applying advanced composites, and more specifically FRP reinforcement, in the construction sector.
- PhD students, scientists and teachers seeking specialist knowledge on the use and design of FRP reinforcement.

The fib/endure/COST FRP training course is taking place 23-27 January 2017 at Ghent University. It is an organisation by fib (Task Group 5.1 and Commission 5), the Marie Curie project 'endure' and COST action TU1207, with the support of the Engineering Society ie-net, the Belgian Concrete Society and the UGent Institute for Post-Academic Education

The course is taught by international expert in this field:
Prof. Valter Carvelli  Politecnico di Milano

Valter Carvelli is Associate Professor of ‘Mechanics of Solids and Structures’ at Politecnico di Milano. The main research interests are in the field of the mechanical behaviour of composite materials and the application of composites as internal reinforcement in concrete structural components.

Dr. Christoph Czaderski  Empa

Empa is an interdisciplinary research and services institution for material sciences and technology development within the ETH Domain in Switzerland. Christoph Czaderski is senior researcher at the Structural Engineering Research Laboratory of Empa. He has two main research areas: prestressed fibre reinforced polymers for strengthening of concrete structures and iron based shape memory alloys for strengthening and reinforcing of concrete structures.

Prof. Joaquim A. O. Barros  University of Minho

Joaquim A. O. Barros is Full Professor of the Department of Civil Engineering of Minho University and coordinator of the Structural Composites Group. His research interests include structural strengthening, composite materials, fibre reinforced concrete and the development of constitutive models for the simulation of the behaviour of cement based and polymer based materials, and their implementation in software based on the finite element method (FEM).

Dr. Maurizio Guadagnini  University of Sheffield

Maurizio Guadagnini is a senior lecturer in the Department of Civil and Structural Engineering at The University of Sheffield, UK. He has extensive research experience in the experimental investigation and use of advanced composites as reinforcing materials for concrete structures. Dr Guadagnini is the coordinator of the MC ITN endure, Chair of COST Action TU1207 on Next Generation Design Guidelines for Composites in Construction and Secretary of fib Task Group 5.1 on FRP Reinforcement for Concrete Structures.

Prof. Renata Kotynia  Lodz University of Technology

Renata Kotynia is Professor of Lodz University of Technology (TUL). She is a Vice-President of IIFC. Her expertise relates to structural strengthening of RC structures with fibre reinforced polymer composite (FRP) materials. She has extensive research and field experience in FRP prestressing of existing RC and post-tensioned concrete structures, and use of FRP reinforcement for new concrete and prestressed structures.
Prof. Stijn Matthys  
**Ghent University**

Stijn Matthys is full professor on renovation of civil structures at Ghent University, Magnel Laboratory for Concrete Research, furthermore he is manager of the Ghent University DuraBUILDmaterials knowledge cluster. His expertise relates to structural renovation of civil structures, fibre reinforced polymer (FRP) reinforcement, structural behaviour of concrete structures, damage diagnostics and monitoring, and technologies for durable building materials and techniques.

Prof. Lluis Torres  
**University of Girona**

Lluis Torres is Professor of Structural Engineering at the University of Girona, Spain. His research interests include behaviour of concrete structures, and more specifically the use of fibre reinforced polymers (FRP) as materials for reinforcing and strengthening of concrete structures.

Prof. Thanasis Triantafillou  
**University of Patras**

Thanasis Triantafillou is Professor of Civil Engineering at the University of Patras, Greece. He has extensive research experience in the field of advanced structural materials, with a focus in the use of polymer or cement-based composites as strengthening and seismic retrofitting materials for concrete, masonry and timber structures.

Prof. György L. Balázs  
**Budapest University of Technology**

György L. Balázs is a professor of structural engineering at the Budapest University of Technology and Economics. He is also the past President of the International Federation for Structural Concrete (fib). While he was responsible for the whole PhD studies at the Faculty of Civil Engineering in Budapest, he founded the International PhD Symposium in Civil Engineering for candidates who are elaborating their scientific research. It was founded in 1996 and since then gained international recognition.
## Programme

### Monday 23 January 2017

**module 0 – Introduction to FRP materials**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00 - 13:00</td>
<td>Arrival &amp; registration - sandwich lunch</td>
</tr>
<tr>
<td>13:00 - 13:15</td>
<td>Welcome &amp; intro (S. Matthys, M. Guadagnini, G. Balazs)</td>
</tr>
<tr>
<td>13:15 - 14:45</td>
<td>Introduction to the subject and industry perspective (S. Matthys)</td>
</tr>
<tr>
<td>14:45 - 15:15</td>
<td>Break</td>
</tr>
<tr>
<td>15:15 - 16:45</td>
<td>Micromechanics of FRP, constituent materials and relationships (G. Balazs)</td>
</tr>
<tr>
<td>19:30 - ...</td>
<td>Welcome drink &amp; dinner</td>
</tr>
</tbody>
</table>

### Tuesday 24 January 2017

**module 1 – Training on FRP materials and FRP for prestressed concrete**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 - 08:30</td>
<td>Arrival</td>
</tr>
<tr>
<td>8:30 - 10:00</td>
<td>Bond of FRP to concrete, material testing and QC of FRP (C. Czaderski)</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>Break</td>
</tr>
<tr>
<td>10:30 - 12:00</td>
<td>FRP for prestressed applications - new and strengthening (R. Kotynia)</td>
</tr>
<tr>
<td>12:00 - 12:45</td>
<td>Lunch break</td>
</tr>
<tr>
<td>12:45 - 14:00</td>
<td>Practitioners speaking</td>
</tr>
<tr>
<td>14:00 - 14:15</td>
<td>Task assignment &amp; intro to lab session (S. Matthys)</td>
</tr>
<tr>
<td>14:15 - 14:45</td>
<td>Break</td>
</tr>
<tr>
<td>14:45 - 17:00</td>
<td>Laboratory work &amp; group work</td>
</tr>
<tr>
<td>21:00 - ...</td>
<td>Ghent by night event</td>
</tr>
</tbody>
</table>

### Wednesday 25 January 2017

**module 2 - Training on strengthening with FRP**

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 - 08:30</td>
<td>Arrival</td>
</tr>
<tr>
<td>8:30 - 10:00</td>
<td>Flexural strengthening design (S. Matthys)</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td>Break</td>
</tr>
<tr>
<td>10:30 - 12:00</td>
<td>Shear strengthening design (J. Barros)</td>
</tr>
<tr>
<td>12:00 - 12:45</td>
<td>Lunch break</td>
</tr>
<tr>
<td>12:45 - 14:15</td>
<td>Confinement and seismic retrofitting (T. Triantafillou)</td>
</tr>
<tr>
<td>14:15 - 14:45</td>
<td>Break</td>
</tr>
<tr>
<td>14:45 - 16:15</td>
<td>Design examples</td>
</tr>
<tr>
<td>16:15 - 17:00</td>
<td>Group work</td>
</tr>
</tbody>
</table>
### Thursday 26 January 2017

**module 3 - Training on internal FRP reinforcement**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 - 08:30</td>
<td><strong>Arrival</strong></td>
</tr>
<tr>
<td>8:30 - 10:00</td>
<td>FRP flexural reinforcement (L. Torres)</td>
</tr>
<tr>
<td>10:00 - 10:30</td>
<td><strong>Break</strong></td>
</tr>
<tr>
<td>10:30 - 12:00</td>
<td>FRP shear reinforcement (M. Guadagnini)</td>
</tr>
<tr>
<td>12:00 - 12:45</td>
<td><strong>Lunch break</strong></td>
</tr>
<tr>
<td>12:45 - 14:15</td>
<td>Durability of FRP reinforced concrete structural elements (V. Carvelli)</td>
</tr>
<tr>
<td>14:15 - 14:45</td>
<td><strong>Break</strong></td>
</tr>
<tr>
<td>14:45 - 16:15</td>
<td>Design examples</td>
</tr>
<tr>
<td>16:15 - 17:00</td>
<td>Group work</td>
</tr>
<tr>
<td>19:30 -</td>
<td><strong>Good-bye dinner</strong></td>
</tr>
</tbody>
</table>

### Friday 27 January 2017

**module 4 - Hands-on training on FRP behaviour and site visit**

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 - 08:30</td>
<td><strong>Arrival</strong></td>
</tr>
<tr>
<td>8:30 - 12:00</td>
<td>Lab demonstrations, visit and competition</td>
</tr>
<tr>
<td>12:00 - 12:45</td>
<td><strong>Lunch break</strong></td>
</tr>
<tr>
<td>12:45 - 14:00</td>
<td>Site visit</td>
</tr>
<tr>
<td>14:00 - 15:30</td>
<td>Closing session</td>
</tr>
</tbody>
</table>
About Ghent

Ghent is without doubt one of the most beautiful historic cities in Europe and was given several pretty names: historic heart of Flanders, a city of all times, medieval Manhattan, Europe’s best kept secret and received some international tourist nominations. In 2008 National Geographic Traveler Magazine ranked Ghent third in its list of 109 most authentic destinations. In the 2011 edition of the Lonely Planet’s ‘Best in Travel’ guide, Ghent took the 7th place on the list of must-see cities. The city was founded in the 7th Century, on the confluence of the rivers Scheldt and Lys, and called ‘Ganda’. During the Middle Ages, Ghent was a leading town, a metropolis, the largest city north of the Alps, after Paris, and larger than London and Cologne. Under the French domination, the city lived stirring times, but in the 19th century, when Ghent came under Dutch rule, the economy flourished again and Ghent developed into a modern city.

Nowhere else can you find so much history per square metre as in the beautifully renovated and fully pedestrianised historic city centre. Three grand medieval towers form the city’s unique skyline. The Castle of the Counts’ impressive walls and merlons let your imagination run wild. The adoration of the Mystic Lamb by the Van Eyck brothers is only one of the many art treasures in the St Bavo’s Cathedral. The Belfry and the beguinages, tranquil oases of peace, are classified as world heritage sites by Unesco.

Ghent is the largest university town in Flanders. The presence of this young population leaves a dynamic mark on the city and this surely adds to the lively atmosphere that Ghent exudes. Ghent University has an international reputation and is a preferred university for prominent scientists.
About the University

Ghent University is a top 100 university and one of the major universities in Belgium. Our 11 faculties offer a wide range of courses and conduct in-depth research in both exact and social sciences.

Ghent University, abbreviated to UGent, was founded in 1817 by King William I of Orange. The past 200 years, Ghent University employed many eminent scientists such as Nobel Prize winners Corneille Heymans and Maurice Maeterlinck, Leo Baekeland, Joseph Guislain, Walter Fiers, Marc Van Montagu, Peter Piot,... You'll also find many prominent persons among our alumni such as Robert Cailliau (co-inventor of the Internet), Dirk Frimout (astronaut), Peter Piot (United Nations) and Jacques Rogge (former Chairman IOC).

Today, Ghent University is a top 100 university and one of the major Belgian universities counting over 45,000 students, 9,000 employees and 117 faculty departments. These departments offer more than 230 high-quality courses in every one of their scientific disciplines, each inspired by innovative research.

UGent distinguishes itself as a socially committed and pluralistic university in a broad international perspective.
How to get to Ghent

**BY PLANE**

Brussels International Airport (Zaventem) is well connected to countries all over the world. At the airport there is an underground railway station. About 4 trains per hour leave to Brussels (trip takes about 15 min). Main stations at Brussels are ‘Brussel-Noord/Bruxelles-Nord’ (first one coming from the direction airport), ‘Brussel-Centraal/Bruxelles-Central’ and ‘Brussel-Zuid/Bruxelles-Midi’. Continue at one of these stations with a direct train Brussels-Ghent (trips takes about 35 min), which will stop at ‘Gent Sint-Pieters’ railway station. Travel information: [www.b-rail.be](http://www.b-rail.be). If your hotel is downtown, continue by tram 1 (each 6 minutes, trip downtown takes about 15 minutes) to the city centre. Alternatively take a taxi. If you’re flying on Charleroi airport, take one of the (blue) shuttle buses that depart just outside the airport terminal every 30 minutes. The shuttle brings you to the train station ‘Brussels South’ (‘Brussel-Zuid/Bruxelles-Midi’) in approximately one hour.

- **Remark 1**: Some of the direct trains to Ghent can be taken at the ‘Brussels National Airport’ station itself.
- **Remark 2**: At Brussels or Brussels National Airport also indirect trains to Ghent are available. Those take however much longer.

**BY CAR**

Ghent is at the intersection of the highways E17 and E40

**BY PUBLIC TRANSPORT**

Most international trains (including both the Thalys and the Eurostar) arrive at the train station ‘Brussel-Zuid/Bruxelles-Midi’, continue by direct train Brussels-Ghent to ‘Gent Sint-Pieters’ railway station (see as described above).

[Eurolines](http://www.eurolines.com) and [Flixbus](http://www.flixbus.com) offer a direct bus connection to the train station ‘Gent-Sint-Pieters’ from nearly every big town in every European country.

Ghent city has an efficient tram and bus line network. More info: [www.delijn.be](http://www.delijn.be). Tram line 1 connects ‘Gent Sint Pieter’ railway station with downtown Ghent.
How to get to the Magnel Laboratory

The teaching venue is at the Magnel Laboratory for Concrete Research, which is building 904 located at the Technology Campus (‘Technologiepark-Zwijnaarde’) of UGent just at the boarder of the city. From the 'Sint-Pieters' railway station, the Magnel Laboratory can be reached as follows.

Option 1:
Take the Campus Shuttle Bus. This dedicated shuttle bus service is available every 15min between 7u30-9u30 and between 16u30-18u30. The pick-up point is located at the 'De Lijn' bus stop at the back of the railway station (Voskenslaan). The first bus stop at campus is nearby building 904. The shuttle bus is free, identify yourself at the bus driver as visiting UGent student.

Option 2:
From the 'Sint-Pieters' station there are many public buses:
49 - Gent - Herzele - Geraardsbergen
70 - Oostakker - Gent - Zevergem
71 - Oostakker - Gent - Nazareth Dorp
72 - Oostakker - Gent – Merelbeke Molenhoek
For more information check the website www.delijn.be
Accommodation

Accommodation costs are not included in the registration fee and participants are expected to make their own arrangements.


Option 1: Stay in one of Ghent’s many hotels, some suggestions are listed below.

**Near Sint-Pieters Station:**
- NH Gent Sint-Pieters
- Chamade
- Europahotel Gent
- Carlton Hotel Gent

**In the City Center:**
- NH Gent Belfort
- Hotel de Flandre
- Ghent River Hotel
- Hotel Gravensteen
- Marriott Hotel
- Hotel Harmony
- Novotel
- Monasterium Poortackere
- Ibis Gent St Baafs Kathedraal
- Ibis Gent Opera

Option 2: Alternatively, Ghent also has a number of cheaper hostels/Bed&Breakfasts, some suggestions are listed below

- Ecohostel Andromeda
- Hostel Uppelink
- Hostel Flandria