

# EUREKA PROJECT E!1098 - EUROCARE EUROCRETE

## 1. General description

<b>Project</b>	E! 1098 - EUROCARE EUROCRETE	<b>Status</b>	Finished - 25-AUG-1997
<b>Title</b>	<b>The Development Of Non-Ferrous Reinforcement Of Concrete Structures</b>		
<b>Class</b>	Sub-Umbrella	<b>Technological area</b>	New Materials
<b>Start date</b>	01-JAN-1994	<b>End date</b>	01-JAN-1998
<b>Duration</b>	48 months	<b>Total cost</b>	6.19 Meuro
<b>Partner sought</b>	No		
<b>Summary</b>	25% Of European Road Bridges/Engineering Structures Are Affected By Carbonation/Cl <sub>2</sub> Attack On Steel Reinforcing Bars.Non-Ferrous, Corrosion-Resistant Re-Bars (Glass/Aramid/Carbonfibre Reinforced Polymer Composites) Will Be Developed		

## Budget and duration

Phase	Budget(Meuro)	Duration (Months)
Definition phase	1.49	33
Development stage	0.75	4
Research stage	3.95	42
<b>Total</b>	<b>6.19</b>	<b>48</b>

## Member contribution

Member	Contribution	Position	Since
<b>United Kingdom</b>	<b>57.00%</b>	<b>Notified Finished</b>	<b>25-AUG-1997</b>
Switzerland	6.00%	Notified Finished	25-AUG-1997
France	11.00%	Notified Finished	25-AUG-1997
The Netherlands	4.00%	Notified Finished	25-AUG-1997
Norway	22.00%	Notified Finished	25-AUG-1997

## Participants

Company	Country	Type	Role
<b>Euro Projects (Lttc) Ltd.</b>	<b>United Kingdom</b>	<b>SME</b>	<b>Main</b>
Vetrotex International S.A.	France	Large company	Partner
Reinforcement Division Of The Saint-Gobain Group			
Statoil - Den Norske Stats Oljealshap A/S (Trondheim)	Norway	Large company	Partner
Sir William Halcrow & Partners Limited	United Kingdom	Large company	Partner
Dsm N.V. (Heerlen)	The Netherlands	Large company	Partner
Sintef - Materials Technology	Norway	Research Institute	Partner
Laing Technology Group	United Kingdom	Large company	Partner
Gec Reinforced Plastics Ltd.	United Kingdom	Large company	Partner
University Of Sheffield/Civil & Structural	United Kingdom	University	Partner

## Participants

<b>Company</b>	<b>Country</b>	<b>Type</b>	<b>Role</b>
Engineering Dept.			
Dsm Resins N.V. (Zwolle)	The Netherlands	Large company	Partner
Du Pont De Nemours International S.A.	Switzerland	Large company	Partner
Norsk Hydro A/S (Stabekk)	Norway	Large company	Partner
Allied Steel & Wire Construction Systems Ltd.	United Kingdom	Large company	Partner

## 2. Project outline

### Project description

Over recent years the long term durability of reinforced concrete has become a major concern in the construction industry. Corrosion of steel reinforcement due to carbonation or chloride attack can lead to spalling of the concrete cover and loss in structural integrity. This can only be restored by expensive refurbishment which is often many times the cost of the original structure. Non-ferrous reinforcements are now actively being considered by designers and specifiers across the world as a replacement for traditional steel reinforcing bars. Reinforcement based principally on glass, aramid and carbon fibres when combined with a polymer matrix offer a number of potential benefits which include corrosion resistance, design flexibility, ease of use and high strength. However, before these materials can become generally accepted it will be necessary to overcome significant materials, performance, production and design barriers. These are currently restricting the market penetration of polymer composites due to lack of proven track record and low consumer confidence. The purpose of this project is, therefore, to develop the materials, automated on-line process, design guidelines and applications for continuous fibre-reinforced plastics in concrete structures.

#### Phase I:

During the initial phase of the research project, work will be undertaken to develop special-purpose composite material systems which consist of resins and fibres that are inherently corrosion-resistant, mutually compatible and easily fabricated into the shapes required. Candidate materials include glass, carbon and aramid fibres together with polyester, vinyl ester and thermoplastic matrices. Attention will be placed on fibre sizing and the possibilities of using both hybrid resin and fibre types. Process research will be undertaken to establish the most suitable production route to enable cost effective volume production of complex 2D and 3D reinforcement systems. Specific attention will be focused on quality control and surface characteristics with resin transfer moulding (RTM), pultrusion and fibre placement being candidate processes. A significant amount of vital basic materials research will be conducted in this phase on both the composite re-bar materials and concrete systems containing them. This will establish important mechanical, physical and durability performance data which will be essential in determining design guidelines relevant for the processing and use of composite reinforcing bar systems.

#### Phase II:

During Phase II of the project, a number of case study components of varying complexity, from applications such as coastal defence, abutments and bridge decking will be examined. This phase will involve utilising the materials developed during Phase I, establishing the optimum processing conditions, the construction of special-purpose process machinery and the development of suitable monitoring equipment to enable full data capture on the performance of the case study components.

#### Phase III:

The aims of this phase of the project are to link all the individual process elements together to demonstrate an automated manufacturing process for the selected prototype components and to undertake extensive trials on the case study components to validate their performance and quality. From this data codes and standards will be established for the confident use of polymer composite reinforcing bar systems in structural concrete subjected to highly corrosive environments.

### 3. Process Technology:

The development of effective processing routes will be key to the future exploitation of this technology. Specific development will be focused on the following areas:

- \* development of processing techniques based on RTM, pultrusion and filament arranging to enable the production of parts suitable for applications in reinforced concrete
- \* development of processing technology for manufacture of thermoplastic reinforcing bar components
- \* development of on-line monitoring and process control systems to ensure product reliability, quality and consistency
- \* understanding of how the key process variables interact with the mechanical and corrosion performance of products
- \* development of the key processing stages into a process demonstrator which links the individual elements together into a pilot cell for effective technology transfer.

### 4. Concrete Reinforcement Technology:

The development of workable codes of practice and design guidelines for polymer composite reinforced concrete will be a key output from this project. The specific developments are given below:

- \* understanding of the basic materials and design information for polymer composite reinforcing bars, specifically relating to long term durability
- \* development of product design guidelines including shape, size, surface finish, distribution and assembly techniques
- \* development of concrete theory which accommodates reinforcement by non-ferrous materials (i.e. crack widths, spacing, required bonding, reinforcement efficiency, failure mode, etc.).

### 5. Structural Concrete Technology:

Structural concrete technology will be developed to a level whereby structures will be capable of reliably withstanding highly corrosive environments with enhanced long term durability performance. During the project case study applications currently manufacturing in traditional materials will be re-designed and manufactured with polymer composite reinforcing bars. The performance of these components will be determined by extensive in-service trials using smart monitoring facilities developed for this purpose during the project. Specific developments will include:

- \* development of systems for in-service data capture and retrieval
- \* development of case study components for extensive field trials
- \* understanding of the long term behaviour of polymer composite reinforced concrete structures.

## Technological development envisaged

This research project will address 5 key technology areas:

#### 1. Resin Technology:

A narrow range of resin specifications will be developed to ensure that their function as reinforcing bar matrix materials is optimised by considering specifically the service environment. Resin systems based on thermosetting polyester and vinyl ester precursors singly and in hybrid forms will be optimised in terms of their long term durability, mechanical performance, ease of processing, cost and environment effects. The potential for using thermoplastic matrices such as polypropylene and nylon will also be established and their advantages in terms of post-formability determined.

The specific developments are:

- \* full understanding of the service environment and its interaction with the matrix materials specifically relating to high pH levels (> pH 11.5)
- \* determination of valuable long term durability data for a range of thermosetting and thermoplastic resin systems
- \* understanding and optimisation of the fibre/matrix interface for enhanced corrosion performance
- \* the development of a validated and approved materials specification including allowable tolerances for matrix systems for reinforcing bar applications
- \* development of fast, high quality, processing routes based on RTM, pultrusion and filament arranging with the objective of developing a demonstrator facility producing a range of demonstrator reinforcing bar components.

#### 2. Fibre Technology:

The development of special-purpose fibres with compatible sizes and suitable finish will be key to providing reinforcement with excellent corrosion resistance, the required product performance, mechanical performance and processability. Specific developments include:

- \* understanding the relative merits of various glass fibre types in the concrete environment (including E, R, ECR, Chem-fil, etc.)
- \* understanding and optimisation of the fibre sizing and coupling agents for long term durability
- \* understanding the relative merits of utilising hybridised fibre types
- \* development of suitable fibre finish and tex counts for onward processing into reinforcing bars.

Note under Relationship to other EU Programmes:

The project follows a preliminary feasibility study recently completed by EURO-PROJECTS (LTTC) LTD. and with the support of the DÉPARTEMENT OF TRADE AND INDUSTRY. There is currently a BRITE programme (BE 4142) running which is concentrating on the use of polymer composite materials for pre-stressing tendons in bridge structures and as such complements the work proposed in this project.

## Markets application and exploitation

The initial focus of the project is on the civil engineering industries and the main application being the replacement of steel reinforcing bars in structural concrete with those constructed from polymer composites. The replacement of steel reinforcement with non-ferrous systems is anticipated to result in an immediate improvement in long term durability of structural concrete

which is exposed to corrosive environments. The use of these materials will also result in structures less prone to deterioration as a result of poor construction practice. It is estimated that, with a very conservative market penetration of 2-3%, a doubling of the European pultrusion market would result (i.e. over 60,000 tonnes per annum (260,000,000 ECU).

The additional design flexibility and low maintenance envisaged for these materials are expected to show substantial life time cost savings on structures susceptible to corrosion. In the longer term, it is envisaged that this project may lead the way towards more efficient reinforcement techniques for concrete structures and lead to a far greater usage of polymer composite materials in this industry sector.

**DSM:**

will exploit the technology by selling increased volumes of special purpose (i.e. corrosion resistant, durable) resins into the civil engineering applications. This is anticipated to represent an immediate new market in the region of 1000 tonnes per annum for stainless steel replacement.

**VETROTEX and DU PONT:**

will exploit new high strength, corrosion-resistant reinforcements from within their product range. This would represent an immediate growth in the civil engineering market in the region of 1500 tonnes per annum.

**STATOIL:**

will exploit the technology developed by selling over 500 tonnes per annum of thermoplastic composite materials and utilise the processing, knowledge gained to establish other volume market opportunities.

**GEC:**

will be able to benefit from being able to manufacture and sell high quality, corrosion-resistant reinforcing systems into the structural concrete industry.

**SIR WILLIAM HALCROW & PARTNERS LTD:**

will be in a prime position to benefit from the project by applying the results to specify, design and project manage leading edge construction programmes which utilise non-ferrous reinforcement systems.

**LAING:**

will benefit from being in the leading position to apply best practice techniques whilst working with novel polymer composite reinforcement and from the sale of complete monitoring systems for in-service assessment of structures.

**NORSK HYDRO:**

will benefit from being in a position to specify and operate low maintenance durable structures, thereby being in an advantageous position to product more cost effective materials.

**NORWEGIAN CONTRACTORS:**

will benefit from being able to utilise and apply the findings of this programme to major construction projects in Scandinavia.

**EURO-PROJECTS, SHEFFIELD UNIVERSITY and SINTEF** will be able to exploit the findings by transferring technology to other user companies, industrial sectors and undergraduate students through demonstrations, papers, conferences and lectures.

**ALLIED STEEL & WIRE:**

will exploit the technology by adding a further corrosion-resistant product to their range of

reinforcements when fully developed.

## Project codes

### **BSI**

DJE/DKT	non-metals
DY	polymers
G	environmental and safety engineering
RBI/RBT	urban and rural works
TJG	corrosive-resistant materials
VU	cement and concrete technology

### **NACE**

2416	Manufacture of plastics in primary forms
2470	Manufacture of man-made fibres
266	Manufacture of articles of concrete, plaster and cement
4521	General construction of buildings and civil engineering works
4525	Other construction work involving special trades
6321	Other supporting land transport activities

### 3. Main participant

**Company** **Euro Projects (Lttc) Ltd.**  
Fowke Street, 1-3  
Le7 7pj Rothley  
United Kingdom

Tel +44 116 237 6693  
Fax +44 116 230 0989

**Contact** **Mr. Gerard S. Boyce**  
Director

Tel  
Fax

[g.boyce@europrojects.co.uk](mailto:g.boyce@europrojects.co.uk)

**Organisation type** SME  
**Participant role** Main

---

### Contribution to project

- project management and co-ordination - mechanical testing facilities - microscopy and NDT (non-destructive testing) - composites design. Contribution: 1000 kECU.

---

### Expertise

A composite materials research and development company specialising in process development, quality control, design, technology transfer and project management.

---

### 4. Partner

**Company** **Vetrotex International S.A. Reinforcement Division Of The Saint-Gobain Group**  
Quai Des Allobroges, 767  
730 09 Chambéry  
France

Tel +33 4 79 96 83 05  
Fax +33 4 79 96 83 50

**Contact** **Mr. Didier Muller**  
Technical Manager Cem-Fil

Tel +33 4 79 75 54 48  
Fax +33 4 79 75 53 99

[Didier.Muller@vetrotex.fr](mailto:Didier.Muller@vetrotex.fr)



**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- glass processing and preparation facilities - mechanical property and ageing facilities - corrosion test laboratory - pilot production plant facilities.

---

## Expertise

A leading developer and supplier of glass fibre products to a diverse range of industries from leisure to defence.

---

## 4. Partner

**Company** **Statoil - Den Norske Stats Oljealshap A/S (Trondheim)**  
Arkitekt Ebells Vei, 10  
7002 Trondheim  
Norway

Tel +47 73 58 40 11  
Fax +47 73 96 72 86

[www.statoil.no.com/eindex](http://www.statoil.no.com/eindex)

**Contact** **Dr. Bjoern Melve**  
Research Manager

Tel  
Fax

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- thermoplastic polymer processing facilities - design and applications facilities

---

## Expertise

One of NORWAY's leading oil companies and a major user of concrete offshore. In addition, they have recently acquired the manufacturing rights for the Plytron range of thermoplastic composite materials.

---

## 4. Partner

**Company** **Sir William Halcrow & Partners Limited**  
Vineyard House, Brook Green (Hammersmith), 44  
W6 7by London

United Kingdom

Tel +44 207 602 7282  
Fax +44 207 603 0095

**Contact** **Mr. Patrick S. Godfrey**  
Chairman

Tel +44 207 602 7282  
Fax +44 207 603 0095

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- design office - computing facilities - CAD/FE capabilities Contribution: 600 kECU.

---

## Expertise

One of the leading civil engineering consultancies in the U.K.

---

## 4. Partner

**Company** **Dsm N.V. (Heerlen)**  
Het Overloon, 1  
6401 Jh Heerlen  
The Netherlands

Tel +31 45 578 2389  
Fax +31 45 578 2411

[www.dsm.nl](http://www.dsm.nl)

**Contact** **(Contact Not Available)**

Tel  
Fax

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

## Expertise

---

## 4. Partner

**Company**                      **Sintef - Materials Technology**  
Richard Birkelandsvei, 2b  
7465 Trondheim  
Norway

Tel +47 73 59 29 10  
Fax +47 73 59 70 43

[www.sintef.no/units/matek/](http://www.sintef.no/units/matek/)

**Contact**                      **Mr. Tor Arne Hammer**  
Senior Research Engineer

Tel +47 73 59 68 56  
Fax +47 73 59 71 36

**Organisation type**              Research Institute  
**Participant role**                  Partner

---

## Contribution to project

- mechanical property testing of thermoplastics - analytical and modelling facilities

---

## Expertise

The largest independent research institute in Northern Europe. They specialise in materials and concrete research.

---

## 4. Partner

**Company**                      **Laing Technology Group**  
Page Street, Mill Hill,  
Nw7 2er London  
United Kingdom

Tel +44 208 906 5344  
Fax +44 208 906 5297

**Contact**                      **Mr. Guy Hammersley**  
Research Manager

Tel  
Fax

**Organisation type**              Large company  
**Participant role**                  Partner



Tel +44 1142 768 555  
Fax +44 1142 728 910

**Contact**                      **Prof. Peter Waldron**  
Head Of Department

Tel  
Fax

**Organisation type**              University  
**Participant role**                Partner

---

## Contribution to project

- full scale concrete test facilities - mechanical testing facilities Contribution: 500,000 ECU.

---

## Expertise

One of the leading Civil Engineering Departments in the U.K. with access to large-scale test facilities, bridge monitoring expertise and wide experience of coastal defence applications.

---

## 4. Partner

**Company**                      **Dsm Resins N.V. (Zwolle)**  
Ceintuurbaan, 5  
8024 Aa Zwolle  
The Netherlands

Tel +31 38 45 69 569  
Fax +31 38 45 69 500

[www.dsmresins.nl](http://www.dsmresins.nl)

**Contact**                      **Ir. Ben Drogt**  
Application Development Manager

Tel +31 38 28 44 08  
Fax +31 38 54 80 76

**Organisation type**              Large company  
**Participant role**                Partner

---

## Contribution to project

- resin development facilities - corrosion and environment testing facilities - analytical laboratories/mechanical property test lab. - applications laboratory. Contribution: 240 kECU.

---

## Expertise

Leading developer and supplier of polyester and vinyl ester resins. This Division of the multinational company DSM has a varied portfolio of high performance products used, among other things, in the construction, transport and automotive industries.

---

### 4. Partner

**Company** **Du Pont De Nemours International S.A.**  
Chemin De Pavillon, 2  
1218 Le Grand-Sacconex  
Switzerland

Tel +41 22 717 5111  
Fax +41 22 717 5109

**Contact** **Dr. Rene Pinzelli**  
Technical Consultant

Tel  
Fax

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- aramid fibre processing and preparation facilities - analytical facilities - pilot production plant facilities

---

## Expertise

A supplier of high performance aramid fibres under the Kevlar trade name.

---

### 4. Partner

**Company** **Norsk Hydro A/S (Stabekk)**  
Drammensveien, 264  
1321 Stabekk  
Norway

Tel +47 22 43 21 00  
Fax +47 22 73 95 38

[www.hydro.com](http://www.hydro.com)

**Contact** **Mr. Arne R. Hole**  
Engineer - Offshore Construction

Tel

Fax

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- application and design facilities - offshore installations for trials

---

## Expertise

The largest industrial company in NORWAY which is active in oil production, PVC, light metals and fertilisers. They have several concrete platforms in the North Sea.

---

## 4. Partner

**Company** **Allied Steel & Wire Construction Systems Ltd.**  
St. Mellons,  
Cf3 0jy Cardiff  
United Kingdom

Tel +44 1222 471 333  
Fax +44 1222 582 154

**Contact** **Mr. Jeremy Hartley**

Tel  
Fax

**Organisation type** Large company  
**Participant role** Partner

---

## Contribution to project

- corrosion protection expertise - financial/economic analysis - market strategy

---

## Expertise

The U.K.'s leading black bar manufacturer and distributor. The U.K.'s only epoxy-coated manufacturer and distributor.