Appendix VII: Impact Case Studies from the Online Questionnaires

As part of the surveys to the UK academic community and industry, respondents were asked the following question:

"As part of this review, EPSRC is looking for examples where research in civil engineering (particularly that supported by EPSRC) has had a significant impact on the UK society or economy. An example is the introduction into practice of geogrid ground reinforcement technology following an EPSRC-supported programme of research in the early 1980s (see: http://www.jubilee-symposium.co.uk). Do you have an example of where research in ground and structural engineering has significantly transformed civil engineering practice? Please give details here and, if possible, references or contact details that could be used to find out more."

The following responses were received:

1) offshore engineering: platforms, pipelines, anchors etc. 2) tunnelling: TBM operations, compensation grouting, monitoring systems etc. 3) piling: vibro-piling, silent press-in piling, CFA etc.
1) The Eurocodes are transforming CEP, and the UK ground and structural engineering research has contributed a massive amount to their development and implimentation. 2) Work on FRP composites has led to the introduction of these material in new constructions, but also for the repair and strenghning of structures. 3) Work on waste materials (such as ash, demolition waste, waste tyres) has led to the developement of new streams of recycled materials. 4) Work on fibre reinforcements has led to the development of many new types of concrete reinforcements. 5) Work on couplers and connections has led to the development of the precast industry for factory components of buildings. 6) Work on permanent formwork means that a lot less timber formwork is use, speading construction and reducing waste. 7)Work on earthquake engineering has made major impact in the way buildings are designed to resist seismic events and new buildings are a lot more resistant to ground motion. Similar work also contributed towards more efficient strenghening techiques (using FRP) which changed the practice completely. 8) Work on Roller compacted Concrete means that roads are now being constructed using this technique. 9)Many more examples can be given.
1. Fibre optic sensors for marine structures – substantially decrease risk of managing infrastructure 2. FlexiArch bridge system developed under KTP wiht Macrete -used geogrid in a flat pack concrete arch bridge to provide a wholly durable bridge form (see KTP portal) 3. Self compacting concrete and low energy concrete - TSB funded research to which is substantially reducing the carbon footprint of pre cast concrete
1. Routine application of fibre reinforced polymer components for the flexural (and shear) strengthening of existing infrastructure stock. A challenging request because it is not often known when incremental results from EPSRC funded projects have had a major impact on the UK society or economy. Visual case sudies are likely to be for fairly simple products or procedures that are deliverables from research funded by 'small' grants, which from this survey appear to be out of favour.
1. The use of fibre-reinforced polymers to retrofit and prolong the life of our built infrastructure. 2. The use of low-carbon materials in new-build projects.
1. Vibration serviceability research funded by EPSRC into human- and crowd-induced dynamic loading over the last 10 years was fed directly into the current design guidelines in the UK and internationally and is used to design major objects of

infrastructure throughout the world, in particular assembly structures and building floors.
AMGISS Marie Curie RTN has demonstrated the added value that 3D FE can offer in modelling complex soil-structure intercations problems associated with groud improvement, see http://www.ce.strath.ac.uk/amgiss/
CLIFFS programme Climate Imapact Forcasting for Slopes
development of constitutive models for soils which have been widely implemented Monitoring of full scale geotechnical structures feeding into design tools characetisation tools for soils
Development of finite element analysis procedures to assist in the design of deep excavations, tunnels and other geotechnical construction operations.
Development of waste management strategies-particualrly landfill Carbon reduction through energy use in the home
GROUND MOVEMENTS DUE TO TUNNELLING IN JUBILEE LINE UNDERGROUND
I would have thought landfill engineering would be the best example. Consult Powrie at Southampton.
Impact is incremental - it is wrong to look for a single high impact. Change is as a result of progressive movement towards improvement.
It is hard to think of a particular example. All building codes are fundamentally based on research and indeed include empirical relationships based on research. In the field of earthquake engineering the leap from theory to practice is fairly quick and new theories (displacement-based design and performance or consequence-based design methods)in design that have overturned the conventional design methodologies (force-based methods)have been proposed in recent years by US and European researchers. However, it is difficult to say how this has affected the UK society or economy, except that our UK consultancies are producing safer and more economic solutions to designs in seismic countries.
Long-span and lightweight buildings, e.g. see http://www.burohappold.com/BH/SRV_BLD_SE_lightweightstructures.aspx. Most adavances in engineering come from proactice first because practice and industry thinks far more quickly than your average industry-orientated university research group. But some real advances have depended upon real collaboration with academia. Polymer geogrids was one area, this is another.
Modelling, analysis and design of structures in fire at University of Edinburgh (funded by DETR/Industry/EPSRC studentships). This work has completely changed practice at Arup Fire and many other consultants and led to safer and more economic "performance-oriented" designs of many new buildings for fire. Arup has funded a 5 year Readership at Edinburgh in return in addition to supporting many PhD students (many of whom find employment there).
Not significatnly, because in my view there is generally a lack of vision in these disciplines.
Research carried out by Dr Rod Jones on FOamed concrete is having a significant effect on the way this material is being used.
Sadly it would be much easier to cite cases where there were missed opportunities where EPSRC failed to provide timely support in this area, or where initial work was supported and then not sustained through to a conclusion. In particular this is true in

the offshore and energy sector (where admittedly other parties are also to blame for lack of investment). A minor success story was the EPSRC support of pipejacking research (co-funded by water companies and the Pipejacking Association) which led to an improvement in pipejacking practice.
SERC/EPSRC support for earthquake engineering since 1984 has given the UK a leading role in Europe and some other parts of the world, particularly in relation to the security of nuclear power facilities. This applies to both structural and ground engineering. It has enabled UK firms to win contracts throughout the world, which would not have been possible otherwise in areas where earthquakes are a design risk of importance. The consequent contribution to balance of payments has been considerable.
Soil conditioning and lubrication in pipe jacking, tunnelling and microtunnelling (EPSRC GR/R08506/01) Tunnelling and pipejacking practice has been transformed by understanding of importance of the interaction of lubricants and soil conditioning with soils. Contact Professor R J Mair, University of Cambridge rjm50@cam.ac.uk
Structural fire engineering led by Arup Fire London. Contact Dr Barbara Lane <Barbara.Lane@arup.com>
The development of a new structural analysis technique for assessing concrete bridges resulted in tens of millions of pounds in savings to the UK taxpayer since large numbers of bridges that would otherwise have been replaced or strengthened were able to safely continue in operation without any further expenditure. Contact Dr C.Middleton, University of Cambridge crm11@cam.ac.uk. See http://www-civ.eng.cam.ac.uk/brg/papers/brgsrv98/
The development of the EPSRC Earthquake Simulator (shaking table) has enabled UK industry (especially nuclear) to develop seismically safe equipment and facilities. Our seismic and dynamic know-how is being applied to nuclear power station life extension studies, long span bridge performance, and in generating international public awareness and esteem for UK civil engineering, including drawing young people to science and engineering. (Colin.taylor@bristol.ac.uk, 0117-3315746)
The Eureka project EU130: Computer Integrated Manufacture of Constructional Steelwork – CIMsteel (1990s) did have a substantial impact on practice in the steelwork sector. More specifically the CIMsteel Integration Standards (CIS/2) have been widely implemented in software and deployed globally.
The finite element method, initially developed for structural engineering applications, has had major impact in all disciplines.
The UK structural fire safety engineering community has irreversibly and positively changed following the Cardington fire tests conducted in the 1990s and the subsequent EPSRC-funded reserach and analysis. The UK fire safety engineering research community is globally known and is uniquely positioned in this area, but funding from EPSRC is now virtually non-existent in this area and the UK risks losing its position of global leadership (both in research and in consultancy) around this issue.
The use of advanced composite materials for structural repair and upgrade. Contacts - Professor Tim Ibell, Bath (concrete) and Professor Stuart Moy, Southampton (metals)
UK research on structural response to extreme/accidental/dynamic events, and on structural fire engineering has influenced design practice worldwide.
understanding of small strain stiffness of soils has transformed design/analysis for

soil-structure interaction (piezoceramic sensors - improved laboratory testing - improved constitutive models) - general change in geotechnical climate with activity at many different universities and take-up by most serious consultancies
Use of recycled construction and demolition waste in the production of new concrete construction products. This project was funded by industry and government tax credits, not EPSRC. Precast concrete block making companies now using recycled material in new block manufacture.
Use of vegetation to stabililise slopes - Major EU project developed at NTU but expertise lost due to University reorganisation!
Work in Sheffield University (and Durham) on detecting multiaxial behaviour of structural concrete under elevated temperature. This work was the springboard for developing a high level parallel nonlinear finite element analysis code for the integrity assessment of AGR reactor vessels.
1. Use of numerical methods in ground engineering
1.Trackbed Investigation: Journal of the Permanent Way Institution, Oct 2007, Vol 126 part 4, p175 & Jan 2008, Vol 127 part 1, p 7. This has led to better scoping of track renewals. 2.Performance Specifications for Road Pavement Foundations: Journal of the Institution of Civil Engineers, Transport, Vol 157, August 2004, page 143. This facilitates use of local materials and secondary aggregates, leading to improved sustainability.
Air3D computer program developed by Cranfield University Shrivenham Campus is widely used in the UK counter terrorist community to assess blast loading on buildings & structures.
As noted above the industry moves slowly but work at Imperial College, Prf David Nethercot, and the University of Birmingham, Prof Clark, is likely to lead to significant developments in the area of robustness and is already influencing leading designers.
Behaviour of tunnel around pile foundations
Bristol University Interface Analysis Centre projects on lime-based masonry has re-discovered a lost technique to low-carbon high- energy conservation technology
Computer software & internet
Fibre Reinforced Concrete Technology
FRP for engineering structures - carried out for Highways Agency by TRL/Maunsell/Mouchel Use of tyre bales for embankments
I have seen, as a practising engineer, that work on codes of practice for new and long-standing materials can best be achieved using resources from different countries through a properly managed programme.
In the 1980s the development of hard/soft secant walling was part of a spur that opened up the wider adoption of basements in developments. Supporting research into the 'soft' materila was provided by Surrey University
Pretty much anything the Imperial College Soil Mechanics Research Group gets it's teeth into!! (settlements associated with tunnelling, offshore foundations, finite element modelling - their research findings tend to end up being be state-of-the-art design principles for those of us in practice) - the best contact would probably be Prof Dave Potts at d.potts@imperial.ac.uk.
Research into innovative methods of timber construction at Cambridge University that have allowed Ramboll UK to pioneer their use on the UK market (contact Dr

Digby Symons, dds11@cam.ac.uk).
The Marine Technology Directorate generated a considerable amount of research into a variety of technologies that have been implemented offshore. In parallel, came the PhDs that played and continue to play a major role in the offshore industry today.