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Innovation in Construction Technology

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Abstract

The innovations originated in more than 20 countries, and cover all facets of construction, including design, fabrication, construction, rehabilitation, labor, management, equipment, and materials. From simple tools to complex systems, innovation makes construction of higher quality that is less expensive, safer, more beautiful, less environmentally intrusive, and better understood and accepted. It helps preserve and renew the old and makes the new more enduring, it provides much of the spirit and challenges that excites and rives the great industry. One of the major issues to be addressed when coming to construction is the choice of the appropriate material. An already, classical implementation of the field techniques, widely used for construction is Cement, Steel, Glass, Wood etc are the main components of any construction now a days. In recent years, several emerging high strength materials have attracted enormous attention as potential candidates for construction. High strength steels has been used as main part of building for more than 40 years because of its manufacturability and ability to deliver continued tensile improvements as it has been made ever stronger. The innovations in construction here are such that they have helped us improve quality, efficiency and cost effectiveness of construction.
Keyword- AAC, Construction Technology, FCDD

I. LIGHT WEIGHT HIGH STRENGTH CONCRETE WALL PANEL TECHNOLOGY

This is a new generation high strength, lightweight concrete building product developed under collaborative research agreements involving Australia's Commonwealth Scientific and Industrial Research Organization (CSIRO) and private industry group, HySSIL Pvt. Ltd. (HySSIL). The CSIRO commenced researching high strength, lightweight concrete in the late 1990's in response to requests from developers, architects and engineers for a product which could provide the properties of the concrete at significally reduced weight, but which would also have overcome the deficiencies of lightweight concrete products already on the market such as autoclaved aerated concrete (AAC). The first products being developed are wall panels and associated items, to be followed by blocks and then flooring system.

Fig. 1: Light Weight High Strength Concrete Wall Panel Technology

HySSIL is a unique celluar-cementitious product which is approximately half the weight of conventional aggregate based concrete at similar strength ratings which facilities cost effective building designs and reduced transport and erection costs. Densities range from 1000kg/m3 to 1500kg/m3 compared with conventional concrete at 2500kg/m3. Compressive strength that range from 10 MPa to 25 MPa. It also has five times thermal resistance of conventional concrete which translates to highly energy efficient buildings running costs. HySSIL can be used in external and internal applications and can be produced as either load bearing or non-load bearing.

HySSIL has a smooth, robust surface finish which means that finishing costs are lower than that of concrete and AAC. It is highly suitable for external application as dry shrinkage is 40% less than concrete and water resistance is superior to similar strength concrete and AAC. Acoustic properties are comparable with conventional concrete. HySSIL is designed to replace conventional concrete and AAC building products range of residential, commercial, industrial and institutional building applications and engineering structure such as road noise barrier.

II. HYBRID CONCRETE / FRP BRIDGE

Reinforced concrete is a “fiber composite” material (steel fibers in a concrete matrix), but is relatively heavy and prone to corrosion, compare with fiber reinforced polymer (FRP) materials. In the USA alone, the damage to concrete bridge decks caused by salting roads during winter runs into billions of dollars. Research has therefore been directed at the use of fibercomposites in bridge structures. FRP materials are strong, light weight, and corrosion resistant, but are generally quite flexible and can be subject to impact damage.

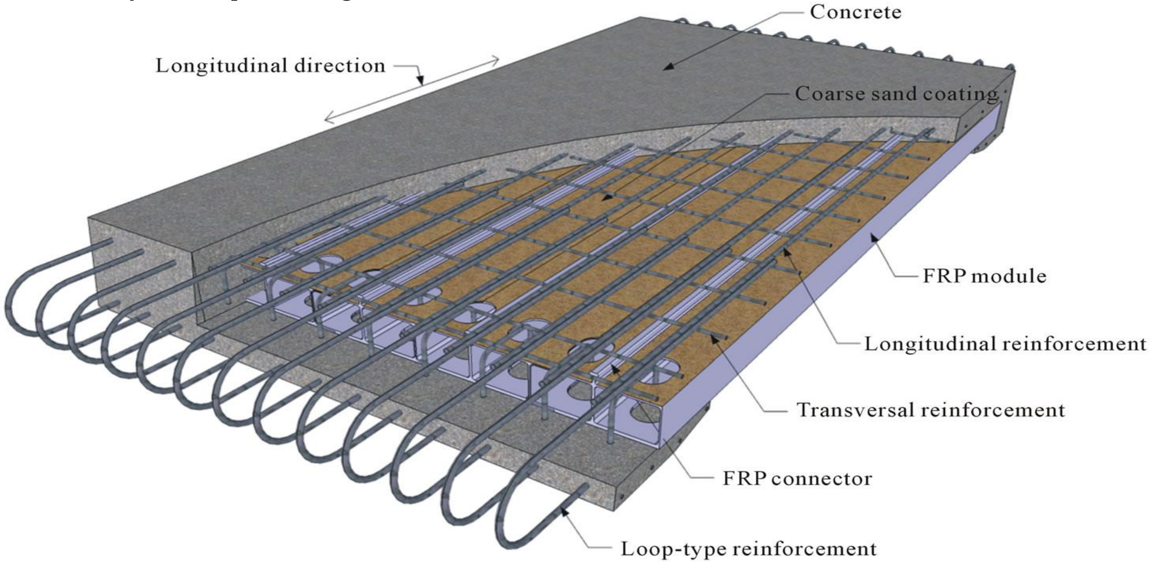

Fig. 2: Hybrid Concrete / FRP Bridge

Fiber Composites Design and Development (FCDD) at the University of Southern Queensland, Australia began considering ways of combining the benefits of traditional bridge building materials such as concrete with FRP materials and developed an innovative new generation composite bridge that outperforms traditional concrete and steel bridges in a number of areas. Traditional reinforced concrete beam concepts can be used as a starting point to illustrate this hybrid concept (see attached figures). For slender concrete beams under flexural loading it is assumed that the strains vary linearly over the depth with compressive strains in the top and tensile strains in the bottom of the beam. The tensile strength of concrete is extremely low and is ignored when determining the ultimate load carrying capacity. Consequently the main load carrying elements of the beam consist of the concrete compression zone (approximately 20-25% of the cross section) and the steel reinforcement.

The two main disadvantages of reinforced concrete beams are the potential corrosion of the reinforcement and the high self-weight. The latter in particular is an important issue given the fact that 75-80% of the material that contributes to the weight (concrete in the tensile zone) does not directly contribute to the overall load carrying capacity. The low cost of concrete is probably the main reason that this has not been a major issue in the past. FRP materials can be used to improve this traditional concept in a number of areas. For example, replacement of the steel reinforcement with FRP reinforcement eliminates the corrosion problem. However, this replacement addresses the corrosion issue only, and does not provide any significant reduction in the self-weight.

With the steel reinforcement replaced by FRP reinforcement, the main function of the cracked concrete is to locate the tensile elements relative to the compression zone. Locating a number of individual reinforcement bars is considerably more difficult than locating a single tensile flange. Hence, replacement of the FRP bars with a continuous FRP tensile flange is a logical next step. A continuous tensile flange can be easily positioned using a single or double web as is common for steel beam cross sections. By orientating the fibers in the web members at $+45^{o}$ and $-45^{0}$the webs are ideally suited to carry the shear forces in the beam thereby eliminating the need for shear stirrups. However, the cracked concrete not only located the reinforcement relative to the compression zone, it also enabled the compression zone to carry localized loads.

In order to reinstate this capability, additional FRP reinforcement is placed under the concrete compression flange. Composite action between the concrete and the FRP reinforcement can be achieved through use of a high quality epoxy adhesive. Finally, additional carbon fiber reinforcement can be added to the tensile flange in order to increase the stiffness of the beam. The final “hybrid” cross section combines both traditional (concrete) and new high performance FRP materials to create a highly optimized structure. The weight of the hybrid beam is about 1/3 that of a concrete beam and due to the elimination of all steel, corrosion problems are basically eliminated. Each component can be tailored to suit specific structural functions, which is economical and resource efficient. Such optimum combination of materials in structural design is becoming increasingly important in a highly competitive society. The hybrid concrete- composites concept has been developed independently by a number of researchers and has been recognized as the way forward.

However, the way in which hybrid mechanisms have been translated into a real beam structure is significantly different in this concept. The failure mechanism of the FRP box beam concept with integral concrete compression flange (to control serviceability deflections) exhibits pseudo-ductile behavior. After development (2001) and extensive evaluation (2002) of the prototype structure (attached illustrations), including testing with a 75 ton GVM mine haul vehicle, the concept was utilized by Wagner’s Composite Fiber Technologies (WCFT) for Australia’s first fiber composite bridge in a road network (documented by the BRITE project of the CRC for Construction Innovation, headquartered at the Queensland University of Technology, Australia). WCFT are proceeding with commercialization of the concept and have recently installed the first bridge of its type in New York State, USA. The leading nature of this innovative concrete/FRP hybrid structure was recently recognized in “Composites Technology” (February 2004).

It demonstrates the need to utilize high performance materials in combination with traditional construction materials in order to achieve the price/performance trade-offs demanded by the bridge infrastructure market. This innovative concept was developed by staff at USQ involved in a collaborative R&D project involving WCFT, Huntsman Chemical Company, NSW and Queensland state road authorities, the Queensland Department and State Development and AusIndustry. Full commercialization of this concept (in progress) will provide bridge and deck structures that combine the robustness of concrete structures with significantly reduced mass, and dramatically better durability

III. THE AUTOMATIC CLIMBING SYSTEM

"Super Climber" is the next generation in self-climbing formwork and working platform technology for high-rise cores. Designed with powerful single-stroke cylinders that support and climb all formwork, platforms and placing boom, it is the fastest climbing system on the market. A single stroke cylinder moves the core with forms, placing boom and all level working platforms into the next level. No need to strip forms into units - a simple ratchet operation is all you need. This keeps the core forms as a single unit and cuts down labor cost and speeds up construction cycle. No shoes or profiles to be climbed or handled. An incorporated leveling mechanism, each lifting up to 90kips-eliminates any extra labor during climbing.

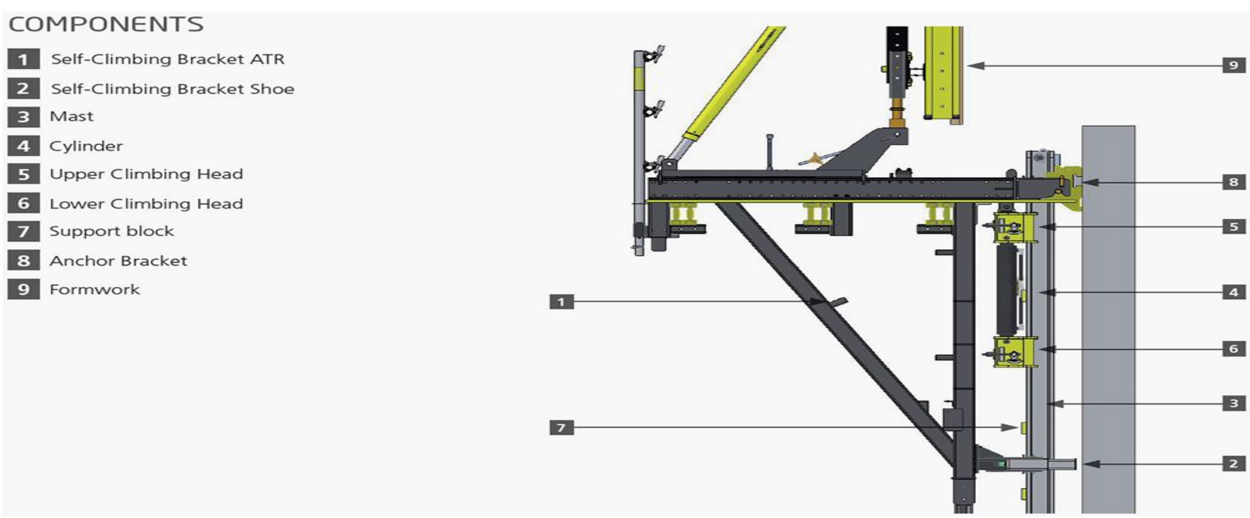

Fig. 3: The Automatic Climbing System

No extra work or bracing required to handle the loads of the biggest placing booms in the market - keeping the cost and labor down. Application With over 2.8 million residents and a constant influx of people, the need for housing in Chicago is never ending. To meet this growing need, new residential condominiums are now being built at 2520 North Lakeview. The 800,000 sq. ft. condo development is built on a standard flat slab. The square column concrete-framed building has two large cores, which are uniquely shaped and have floor-to-ceiling heights that vary throughout. For this particular building design, it is necessary to cycle the vertical formwork at the same speed as the horizontal formwork.

Walsh Construction Company wanted to pour the slab and floors monolithically and needed a forming system that could easily meet those challenges. Additionally, the formwork system had to be capable of carrying a concrete placing boom, provide support for heavy loads (rebar) and be an easy-to-handle system that could keep them on a one-day cycle. For these reasons, Walsh chose Super Climber self-climbing form system with a working platform for high-rise cores. Walsh has been extremely pleased with the Super Climber system and has already committed to use this effective solution on their next concrete core project. The project was delivered at a competitive price because the formwork lowered the man-hour cost. Also, the project will be completed on schedule due to the ability to cycle the formwork floor to floor.

The fastest system on the market The Super Climber system, newest member of their multiple climbing formwork systems, meets the tough requirements of extreme dynamic load ability with swift, smooth climbing. Also,60 automatic climbing formwork is being used on the north core. Using two self-climbing core systems would allow Walsh to cycle the cores as fast as the slabs. Systems allow for prefabrication of panels and platforms, which help limit the amount of onsite work. By using formwork, it allows Walsh to meet their schedule and minimize the amount of man-hours on the project. The 39-story structure needs approximately 2,300 sq. ft. of formwork. There are varying floor-to-floor heights with two double jumps. A total of five Super Climber hydraulic cylinders are used to climb a fully decked Level +1 and Level 0. Custom beams support a concrete placing boom and Framax stripping corners are incorporated into the Top 50 wall formwork for easy stripping relief.

The formwork used includes: the new Super Climber system with Top 50, self-climbing 60 with Top 50, Frami lightweight formwork for columns, MF 240 platforms, 54,000 sq. ft. of Dokaflex slab formwork and 72,000 sq. ft. of restoring materials. Eliminating Crane Time the Super Climber self-climbing core system offers faster cycle times. The system allows the inside and outside forms to be hung from the gantry, which allows the contractor to roll forms, while erecting and stripping. All of the formwork for an entire story is raised independently of the crane. Minimum clearance is required for installation and minimum stripping required for climbing.

The Super Climber is a safe and efficient way to construct high-rise cores. It has room for all of the site equipment needed and is enclosed on all sides for a safe, weather-shielded work area at any height. The live loads on the platform mean that less storage space is needed on the ground. After pouring, the formwork for an entire next story is raised by powerful hydraulic cylinders from one casting section to the next.

IV. SEISMIC ISOLATION BEARINGS

Seismic Isolation Bearings protect buildings, bridges, and industrial facilities from earthquake damage. They are structural supports that use an innovative way to achieve a pendulum motion of the supported structure. By placing these concave spherical bearings at each support point, the structure sways with a gentle pendulum motion during earthquake ground shaking. This allows the ground to shake without damaging the structure. Seismic isolation provides structures with a higher level of seismic protection than conventional structural strength and ductility design. Compared to elastomeric bearings, bearings can be used for a wider range of applications, have simpler and more predictable properties, and are less expensive to install. Simple in design but with versatile properties, bearings have been used in some of the world’s largest seismically isolated buildings, bridges and industrial tanks. Bearings have also been effective and economical for small buildings, bridges, and chemical tanks. Since their conceptual development in 1985 by Dr. Victor Zayas, bearings have been used as the primary seismic protection for 1.6 billion dollars’ worth of civil engineering construction.

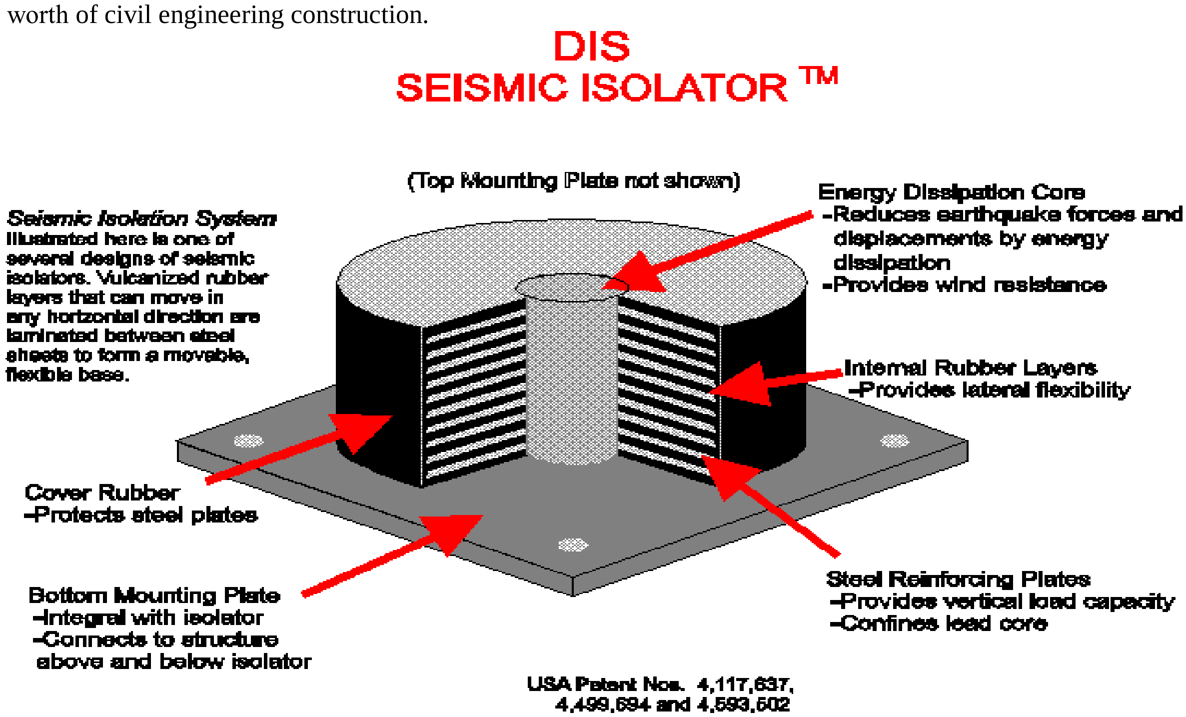

Fig. 4: Seismic Isolation Bearings

A. Application Highlights

- U.S. Court of Appeals
- Liquefied Natural Gas Tanks, Greece
- Benicia-Martinez Bridge

V. SMART BRIDGE TECHNOLOGY

The new I-35W Bridge in Minneapolis, Minnesota is a modern concrete bridge for the future. The 10-lane interstate bridge with a 504' main span across the Mississippi River was opened to traffic on September 18, 2008 to replace the steel truss bridge that tragically collapsed on August 1, 2007. It was designed and built in 11 months through a Minnesota winter while all eyes of the world watched the new futuristic bridge take shape. The bridge is designed to be able to carry rail in the future along with the ability to suspend a pedestrian bridge underneath. The design of the 504' main span over the Mississippi River features 120 precast segments, weighing up to 200 tons each that were assembled in just 47 days.

Fig. 5: Smart Bridge Technology

The bridge "thinks" with innovative, state-of-the-art "smart bridge" technology, utilizes the first use of outdoor LED lighting for a highway and each part of the bridge has custom developed concrete focused on eco-friendly sustainable design. The new bridge achieved the Minnesota Department of Transportation's vision for safety, quality and innovation by incorporating sustainable design and new technologies. Innovative "Smart Bridge" Technology State-of-the-Art Smart Bridge technology comprised of 323 sensors embedded in the concrete during construction monitor bridge behavior in real-time. During construction, the smart bridge systems monitored the temperature of the concrete to ensure high-quality during curing. Over the service life of the bridge, the information collected by the sensors will assist the Minnesota Department of Transportation in managing operations by enhancing bridge inspections with structure performance data, maintaining efficient and safe traffic flow, and providing infrastructure security.

Temperature, humidity and wind speed measurements also trigger the bridge's automated anti-icing system. Information gathered from the sensors will be managed in partnership among the Minnesota Department of Transportation, the Federal Highway Administration and the University of Minnesota's Department of Civil Engineering and will provide valuable feedback about bridge traffic patterns, infrastructure maintenance and security, and design sustainability for future bridges. First use in the United States of LED Highway Lighting Low energy, low maintenance LED highway lighting was used for the first time in the United States on the new I-35W Bridge. The energy savings and effects of this new lighting method are being studied in conjunction with the Department of Energy for future applications throughout America. Preliminary tests show an energy savings of 18% for the LED fixtures when compared to traditional high-pressure sodium (HPS) fixtures. The LED fixtures also offer a significant savings in maintenance costs with a standard life of 10-15 years rather than the required revamping every 4 years for other fixtures.

First major use in North America of Eco-Conscious cement Two 30' tall gateway sculptures that mark the river crossing at each end of the new bridge represent the first major use in North America of a new environment friendly cement that cleans the air utilizing a nanotechnology. When ultraviolet rays from the sun hit the surface of the concrete containing this eco-cement, a photo catalytic reaction occurs removing pollutants from the air. The cement is also self-cleaning, removing contaminants from the surface of the gateway elements.

VI. CONCLUSION

Open innovation is nothing new. Innovations have always openly been achieved despite boundaries and across organizations. It is a fact that ideas always evolve from exchange – the reason why Steven Johnson, author of the book "Where good Ideas come from", sees coffee houses as true idea labs.

The reason why open innovation is popular nowadays is because it empowers us to access new ideas and the social networks build around them, which was not possible before. Innovation hubs act as network nodes with open doors and work in the same way as innovation challenges. People from different disciplines and with different passions come together around a shared purpose. This is the best recipe to bring ideas to fruition. We are constantly witnessing the creation of idea networks, which allows exchanging success stories but also lessons learnt from failures. British author Charles Lead beater in this context refers to systemic innovation and predicts that "systems innovation will become the most important focus for companies and governments, cities and entire societies." In the last decade there has been a growing focus on product and services innovation as a source of competitive advantage.

"This is not the wisdom of the crowd, but the wisdom of someone in the crowd. It's not that the network itself is smart; it's that the individuals get smarter because they're connected to the network." Steven Johnson

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