RUBACON Program

Rejnalda Golemaj [1], Paul Rayar[2]

[1] Rubacon Deputy Director, Albania

[2] Director of ARCILLA Research, Epen, Netherlands

ABSTRACT

Energy, climate change, industrial development and air pollution are critical items on the international agenda. Addressing them in unison creates many win-win opportunities and is crucial for sustainable development.

RUBACON - Resource Utilization for Building And CONstruction is a unit of Arcilla Research that aims to counter climate change and poverty. Our policy is to provide a significant opportunity for communities to recycle their 'waste' materials and create sustainable systems of housing, energy, water and satisfy many other needs at little cost but with high benefit to the environment.

The final materials are neither cements nor ceramics yet offer many of the advantages of both. The chemical inertness, strength, thermal stability, hardness and aesthetic properties of fired ceramics can be obtained. At the same time, curing at ambient temperature, or slightly higher, saves a great deal of energy compared to conventional ceramic production. A further advantage is the ease with which the materials can be shaped either as large flat sheets, hollow beams, contoured shapes, expanded foam structures or fiber-reinforced composites. Their higher strength compared to cement means that thinner, lighter panels or entire structures can be produced. A study at Delft University of Technology, completed in 1988, demonstrated the credibility of this approach. The project, financed by the Dutch Ministry of Housing, made use of secondary resource materials from some 6 countries on 3 continents to produce the test specimens.

The Program includes a group of interrelated projects with the key project, advanced building materials and construction system, at the core. The materials are low to zero carbon and lightweight – gender-sensitive; they may be produced and assembled by women and older children. The construction system is designed to be energy autonomous and stable – providing extremely high resistance to earthquake, storm, fire and flood.

With innovative building technology and a commitment to sustainable development, this paper strives to address these twin problems in both rural and urban settings.

Keywords: Rubacon, advanced building material, little cost, extremely high resistance, Arcilla Research.

INTRODUCTION

In today’s world, rural and urban ‘waste’ has been the cause of many serious environmental problems. Nearly all countries are now well aware of the problem and taking steps to find solutions by encouraging utilisation or recycling. Many governments and individuals are seeking to create beneficial uses for these materials and view ‘waste’ in a positive way. For those in the field, waste (so called) falls mainly into two categories:

Secondary Resources and Renewable Resources. Some of these resources contain harmful chemicals, heavy metals or are in the form of fine particulate powders. These factors may cause ground water or air pollution leading to human health problems and such possibilities must be taken into account [1].

However, if the only options considered for such potentially hazardous materials are incineration or landfill, whilst the option of recycling is ignored, a valuable resource may simply be thrown away. At the same time, the excessively large quantity of these materials still presents a problem with landfill sites frequently restricted and the total amount of such 'waste' increasing dramatically every day. Many studies have been conducted on converting such resources into useful materials, specifically for application in the building and construction industries. For the poorer classes with restricted income, a large need exists for such products that are more affordable than those presently available. For building materials to be produced utilising secondary and renewable resources, and made readily available at a reasonable price, two things are required: a technology for producing such materials and a straightforward system of production [2].

RUBACON PROGRAMME

The RUBACON versions use mineral powders from secondary resources and quartz sand. However, the sand may be replaced by chopped straw, thatching grass or bagasse, resulting in a material that is lightweight and suable. It is believed that the strength properties can be significantly increased by improvement of the granulometry, and high-frequency vibratory or percussion compaction. It is anticipated that RUBACON versions will have properties that far exceed cement/wood chipboard, a material approved in the UK for construction of housing up to three stories.

Incorporation of fine fibres during fabrication substantially increases impact resistance and reduces shrinkage. A composite containing carbon fibres, recently tested in the laboratories of a large engineering firm, gave high bending strength results - nearly 100 MPa. Chemically bonded ceramics show good market growth potential due to the fact that high-performance, cost-effective products can be formed of almost unlimited size, using straightforward, economic production processes.

A wide-ranging programme of ultra-dense materials are poised for commercial development, based on primary, secondary and renewable resources from industries as diverse as mining, manufacturing and agriculture. A new RUBACON binder especially for use with renewable agricultural resources makes these fibres, straws and grasses water repellent. Substitution of sand by enhanced organic aggregate opens up new possibilities, creating a range of lightweight 'Ecomaterials' that is 'gender sensitive'. A short list would include:

- Roof and wall panelling and monolithic shell structures
- Wall, floor and terrace tiling
- Wear and corrosion-resistant flooring, cladding and foundation slabs
- Sewer, duct, water and irrigation piping
- Road building and bridge deck repair
- Corrosion-resistant flooring and elements for the animal husbandry industry
- Agricultural and industrial containers resistant to corrosion and bacteria growth
- Corrosion-resistant protective zinc-free coating of steel
- Internal pipe coating when an impediment-free product flow is desired
- Surfacing of entire interiors to create bacteria-free environments

- Engineering ceramics and electrical insulators
- Seamless, seismic-shock resistant containers for hazardous waste transport and storage

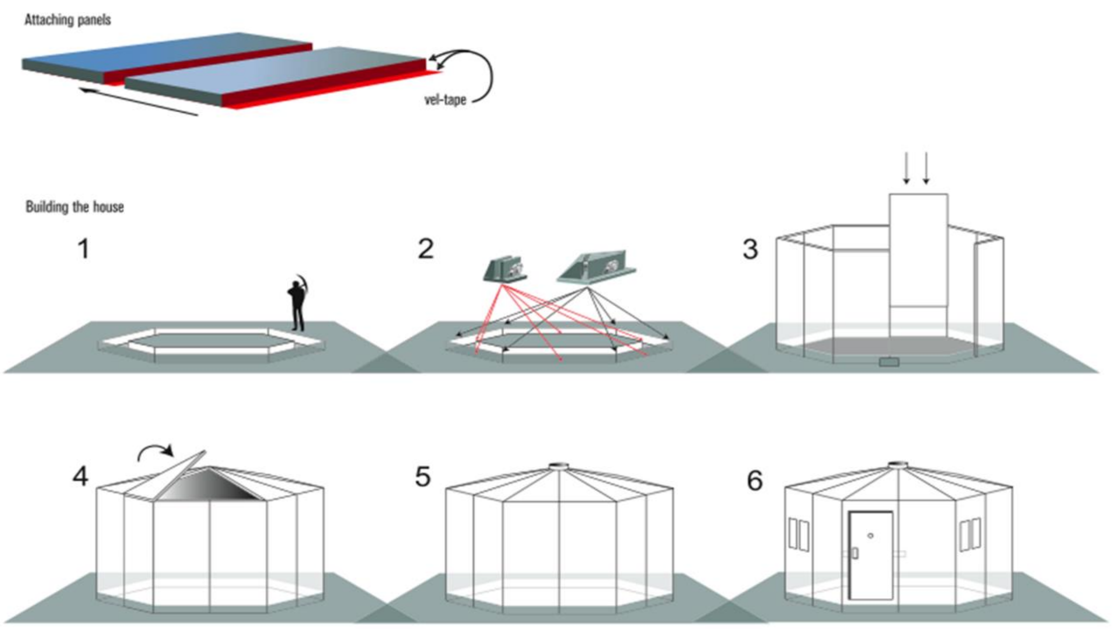

Figure 17 DIY construction system of hexagonal shelter/house, highly resistant to storm and earthquake

At the heart of the RUBACON programme is a body of technology aimed at achieving maximum utilisation of agricultural by-products, grasses and plants. The RUBACON technology would use renewable resources as mineral binder component, fibre, organic additive, wood alternative, soil food and energy source. Implementation would mean creation of a range of new, cost-effective building and construction materials, in tune with the needs of people and the environment. Production of cement extracts large quantities of primary resources from the earth and, at great cost in energy, creates a binder.

INORGANIC MICRO BINDER SYSTEMS

By using agricultural by-products, the first synthesised version of the Arcilla developed mineral binder was created. A study at Delft University of Technology in the Netherlands succeeded in demonstrating the credibility of the new system that employs specific straw, husk and grass ash residue in combination with additives and water.

The key advantages of the process compared to cement are threefold: a 'waste' or secondary resource is converted into a binder and - as a bonus - energy and natural fertilizer is produced. The promising results of the 'Delft' study encouraged Arcilla to proceed with further developmental work on the technology.

Laboratory research led to development of a prototype system for making a straw particleboard bonded with a binder composed of processed straw ash. By replacing straw with fine graded sand, strong, dense materials were made, whilst in a composition using only fine particulate powders, cellular materials with isolative properties resulted.

RUBACON MATERIALS

-Cerafoam Pellets
-Fiberamic
-Cerastraw And Cerawood
-Rubberamic
-Thermal-Shock Resistant Ceramics

CERAFOAM is a lightweight, highly isolative 'cellular ceramic'. It is non-combustible and does not contain or give off any noxious gases, making it safe to use and work with. In spite of its sponge-like appearance, the material is surprisingly resistant to water penetration and can float indefinitely due to its semi-closed cell structure. It is made of essentially 100% fine mineral powders together with a special binder and additives. The low energy requirement (120o C) make it environmentally advantageous and economical on energy and raw materials. It is not only light and isolative, but also strong and heat resistant. Although it could be produced in monolithic sheets or special shapes, for versatility, the pellet form is preferable.

Figure 2 Cerafoam pellets

The structural version of FIBERAMIC, used as the inner panel, is a thin-section, fibre-reinforced sheet material. The composition of fine particulate powders and fine graded aggregate, bonded by the mineral binder system give it high rigidity and fracture toughness. Flexural strengths from 40 to 100 N/mm2 have been achieved with impact resistance and toughness from 2.5 x to >10 x that of conventional ceramics. The features of this material are:

- Compositions may be defined to meet specific target specifications
- Versions can be thin or thick, flexible or rigid, as required
- Choice of fibre may be natural or man-made to meet the specifications
- The total weight of the finished outer panel @ 1 mm thickness is ~ 1 kilo per meter^2
- Protection against intense sunlight and resistance to ultraviolet radiation
- High resistance to heat, fire and water
- The materials may be recycled, are people, environment and pocketbook friendly

Figure 3 Fiberamic

CERASTRAW and CERAWOOD are a group of bonded particle materials with special properties. Initial tests have demonstrated that the materials could be combustion resistant and fire retardant. The materials appear to be quite resistant to water and moisture swelling. The isolative values of these materials are relative to their density. It is expected to be particularly suitable as isolative roofing and walls for animal stalls to protect the animals against the effects of high temperatures during the hot summer months.

RUBBERAMIC has a hard wear-resistant surface yet possesses the soft cushion-like feel of rubber. All of this is achieved without firing and, with properties of toughness and resistance to wear and corrosion, a number of high-impact applications were suggested:

- non-slip road surfaces
- bicycle path surfacing
- playgrounds
- flooring for animal husbandry stalls

Its one less-attractive feature - the black colour - is overcome by colouring with ‘waste’ iron oxide (rust) as well as a range of natural mineral colours. The surface may be smooth, textured or profiled. The process is straightforward; a special ceramic cement (CERMENT) paste is mixed with the polymer and fine chopped fibres. The mixture is formed into the desired shape, such as slab, facing or coating by one of several compaction techniques: extruder, hydraulic press, high-frequency hammer or vibrator. It is believed that spray-forming of the material is also a viable application technique. Curing may be carried out at ambient or room temperature or accelerated by gentle heat up to about 120 o C.

Figure 4 Rubberamic

THERMAL-SHOCK RESISTANT CERAMICS

The latest development by Arcilla is technology for producing thermal-shock resistant ceramics - without firing. It is believed that the new materials could have considerable value to the ceramic industry. The immediate application possibilities suggested are:

a. Creation of a range of well-designed wall, floor and terrace tiles, which upon curing (@ ±150 o C.) may be glazed sans kiln. Whilst the technology makes possible production of tiles and panels with a coated surface, it is now possible to produce surface-glazed tiles, as well, by means of heat treatment with an infrared lamp or other heat source. Surface-glazed tiles would have the

advantage of superior density, hardness and high resistance to the elements (freeze-thaw). The tiles could thus be applied outdoors as terrace tile. Economically, the extremely high thru-put would mean a large savings in energy and labour costs.

b. Surface-glazed buildings would result in buildings that are aesthetically attractive, free of blemish caused by pollution, thus making for a large savings in upkeep costs. A spin-off could well be protection against attack by acid rain, thus avoiding concrete rot. Interior applications would include bacteria-free environments in hospitals, meat markets and the dairy industry. Without the use of mortar grouting, a favourite breeding ground for bacteria in tile walls, the health benefits would go along with the savings in labour costs.

c. Fibre reinforcement would add toughness and impact resistance; a carbon fibre version, tested externally, was shown to have a very high flexural strength of close to 100 Newton and a high modulus of elasticity. Further work is expected to reduce the water absorption from 2 % to 1 %, equal to electro-porcelain fired at ± 1400 o C.

Enhanced natural fibres such as hemp, sisal, coir and flax, by virtue of their price/technical advantages over man-made fibres, could become a stimulus to revitalising agricultural industry. To protect fibres from deterioration caused by moisture, corrosive environments, oxidation at elevated temperatures and flammability, a system composed of two distinct components has been developed:

1. Barrier Sheath
2. Flexible Ceramic Coating

The first component is a water-resistant, water-repellent, flexible film or sizing which, during the process, effectively acts as a barrier against penetration by the liquid ceramic coating, ‘Ceracoat’, which can impregnate porous fibre and rigidize it. The barrier film also protects the fibre, organic or inorganic from the destructive effects of a liquid or gaseous corrosive environment.

Figure 5 Ceracoat, a barrier sheath

The second component, a coating, of special composition, encapsulates the fibre filaments or tow and enhances the protective sheath, insulating the fibre from destruction by heat and preventing penetration by oxygen or water. The coating may be formulated in one of several versions: rigid or flexible, natural white or coloured, opaque or slightly translucent.

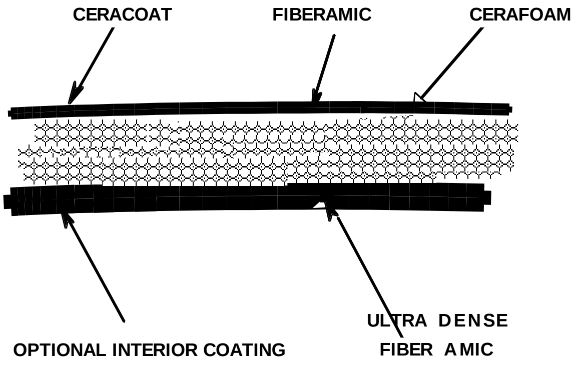

Figure 6 Panel cross section

Figure 7 Water repellent adobe

In combination with the mineral binder as coating and adhesive, the possibilities for creating ecologically friendly materials for building and construction can be realised.
Being chemical, rather than thermal, it is friendly to people, the environment and saving in energy. Compared to cement and synthetic resins, it is less costly and more effective. Two styles of lightweight construction are being designed, both with high resistance to storm and earthquake.

Other applications for these materials are foreseen in agriculture, e.g. construction of animal stalls, storage containers and irrigation pipe. Conventional irrigation pipe is quite heavy and lightweight ‘gender-sensitive’ pipe of bagasse or straw will find ready acceptance by women and children who, in many developing countries, are obliged to take on the task of irrigation.

ADVANTAGES

The new family of 'green performance' materials all share the chemical inertness, strength, thermal stability, hardness and aesthetic properties of fired ceramics. But with a difference - they can be cured at ambient temperature or slightly higher, saving a great deal of energy compared to conventional ceramics. A further advantage is the ease with which the materials can be shaped either as large flat sheets, hollow beams, contoured shapes, expanded foam structures or fibre-reinforced composites. Their higher strength compared to cement means that thinner, lighter
panels or entire walls can be produced in situ.

Building and Construction Materials	RUBACON Technology		Cement Technology	
	Properties		Properties	
Dense	@ 1 cm wall thickness	40 N flexural strength	@ 6 cm. wall thickness	3-7 N Flexural Strength
Cellular blocks and panels	High Insulation Value	200 Kilos m3	Moderate Insulation Value	800 Kilos m3
Coatings	Corrosion Resistant and colour range	Acid, Alkali and Salt Resistant	Requires Protective Coating	Poor resistance to acid and salt
Natural Fibre Composites	Non-brittle and Flexural	High Impact resistance and H2O repellent	Metal Bar Reinforced Concrete	Non-existent as natural fibre composite
Adobe & Earth Materials	Water resistant and repellent	Resistant to erosion and crumbling	Cement Stabilizer	Poor resistance to erosion and crumbling
Adobe & Earth Materials	Cellular Version	High Insulation Value	Technically not possible	
Road Construction	High durability	Low cost and high durability	Cement and Asphalt	Poor durability
Road Repair	Excellent adhesion	Low cost and high durability	Cement and Asphalt	Poor durability
Ceramics	RUBACON Technology		Conventional Ceramics	
Dense	Water Absorption 2%	100 N flexural strength	Water Absorption 6%	Firing required
Surface Glazed	High energy savings	High thru put	Kiln required	Firing required
Metallo-Ceramic	Rust free using waste metal		Kiln required	Fired version

Figure 8 The advantages of RUBACON technology over cement technology

CONTAMINATED EARTH AND SLUDGE, IMMOBILISATION TECHNOLOGY

Contamination of earth, clay and sludge by oil, pesticides, toxic organic chemicals and heavy metals has created serious problems to the environment of almost all industrial countries [4]. At the same time, these very same toxic chemicals pollute many rivers and streams. A recent study at the Arcilla Research Centre in the Netherlands, devoted to finding a solution to this challenging problem, has resulted in development of a three-stage process for treating this category of materials, which renders them virtually immobile. The first stage treatment converts the plastic loam or sludge into a relatively non-plastic material with significantly reduced water absorption. During the second stage, a special ceramic cement

(CERMENT) paste is mixed with the powder and the mixture is formed into the desired shape, such as a round pellet. The pellets are combined with a 'clean' Fiberamic Cerment matrix in the third stage of the process to create a fail-safe system.

The three stages of the process are carried out at temperatures of ~120o C. For cleansing of waterways, zeolites would be used in the first stage to take up the pollutants. The contaminated zeolite material would then be mixed with CERMENT and formed into a dense pellet. In the third stage, bonding of the pellets to form a dense slab would provide a fail-safe protection against leaching.

The objective of the programme is twofold: to develop a highly dense, graded aggregate and secondly, a bonded aggregate version in which water absorption of the pellets is close to nil. Anticipated intended uses for the aggregate material would be as a core layer for road and airport runway construction and land fill foundations.

To sum up the main points of the process:

- The three processes are accomplished at low temperatures of ~120 o C
- Immobilisation is of a very high order, insuring that leaching of potentially hazardous chemicals is eliminated
- Application provides environmental protection and at a fraction of the cost

CONCLUSION

RUBACON aims to bring multi-dimensional benefits to both the rural and the urban areas and people of economically deprived countries. Rural development is an essential component of national economic advancement. Often subjected to isolation and neglect, rural areas are too frequently excluded from the benefits of development initiatives. Urgency for radical change exists, not only if mass migration to the cities is to be prevented, but because vital resources of all kinds are found in the countryside.

The RUBACON technology, utilizing rural resources, is anticipated to stimulate the startup of new enterprises, initiatives that will give fresh impetus to agriculture through its holistic approach. As building materials common to cities: concrete, metal and fired brick and buildings made from such materials are energy wasteful, contributing to climate change, RUBACON believes that a new model of urban development is needed to accommodate the worldwide housing deficiency and the ever-growing crisis of global warming. With innovative building technology and a commitment to sustainable development, this paper strives to address these twin problems in both rural and urban settings.

REFERENCES

[1] Handbook of National Development Plans, Metra Consulting. Cook + Kuhn, Editors.

[2] TIMS: Studies in Management Sciences; Planning Processes in Developing Countries, Vol.17

[3] Investing in Natural Resources, 2nd Edition Youngquist, Walter

[4] TIMS “Planning Development Processes in the Third World: The Construction Sector