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“Sheltron" - - A Construction System For Low-Cost Housing

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"SHELTRON",
A CONSTRUCTION SYSTEM FOR LOW-COST HOUSING

By

Rodolfo J. Aguilar*

INTRODUCTION

All building construction must, during its life span, provide adequate:

1. Safety through its structural strength and stability.
2. Protection from corrosion, decay, insects, and other destructive agents.
3. Resistance to weather, seismic forces and fire.
4. Durability and economy of maintenance.
5. Quality workmanship.
6. Architectural aesthetics.
7. Competitive initial cost.

These seven objectives are fundamental goals to all useful construction methods.

SHELTRON is a controlled gas-entrained concrete construction system that fulfills the objectives given above and that makes possible a limitless variety of economical monolothic structures. It opens new vistas to the creative designer, architect, engineer, land planner, builder, contractor, and developer, as it combines beauty, economy, and rapidity.

DESCRIPTION

The SHELTRON system of construction has been developed through several years of experience in the building industry. A mixture of sand, portland cement, water and special chemicals[1] is sprayed at a very low pressure on a skeleton of steel reinforcing bars covered with mesh or metal lath. The process is so engineered that no formwork is required during the construction stages. This results in a structure that can be built at low cost, simultaneously allowing total freedom to the designer's imagination in creating the architectural concept.

The chemicals added to the mix in the SHELTRON system produce microscopic gas bubbles in the matrix of the material. These gas bubbles have the effect of a ball bearing action which reduces internal friction in the mix, allowing it to flow freely at low pressures; this material is sprayed in layers on the skeletal steel frame. The first layer, called the freeze coat, is applied to wet the lath from the inside without attempting to close all of its pores. A second coat is applied from the outside in successive layers to cover the steel reinforcement to any specified thickness. This is called the build-up coat.

The third coat is applied from the inside again, in successive layers until the desired thickness is obtained.

The final outside layer is made extra dense in order to improve the resistance to moisture penetration. The final inside layer is given any desired finish and it can serve to improve the material's accoustical properties.

Good adhesion of the mix eliminates special surface preparation, rebound, and fall-off. All roof areas are covered with a coating that produces a long-lasting, bondable roof. The entire construction process can be carried out with readily-trained personnel, and does not require the services of highly-skilled technicians; the spraying is done using standard concrete and plaster mixing and pumping equipment.

No wetting down of SHELTRON is required as it sets in fifteen to thirty minutes. It is resistant to rain damage thirty minutes after spraying. Because of its controlled volume expansion, and fast setting, shrinkage cracks are virtually eliminated.

MATERIAL PROPERTIES

SHELTRON is a lightweight concrete, made lighter than normal concrete by the introduction of gas bubbles into the plastic cement mix, producing a material with a cellular structure. The gas or foam bubbles are generated by a chemical reaction which takes place within the fresh mortar mass. When the mix sets, it contains a large number of such bubbles; the larger this number, the smaller the weight and the strength of the mix.

After setting, SHELTRON has a stable structure where the three phases, gas, liquid, and solid, coexist in permanent equilibrium. Its solid phase is composed of cement, sand, and Vinfoam chemicals.

Under the action of the foaming agents, SHELTRON undergoes an increase in volume which approximately amounts to 50% of the wet bulking of the sand volume used in the mix.

SHELTRON is classified as Structural and Non-Structural. Structural SHELTRON has more than 2000p.s.i., 28-day strength, measured on a standard cylinder. Its density varies usually between 95 and 120 p.c.f. Non-Structural SHELTRON has less than 2000 p.s.i. strength, it is used for non-load bearing walls, insulation, and the like, and its density varies usually between 30 to 90 p.c.f.

STANDARD STRUCTURAL MIX AND MATERIALS

SHELTRON is tailored to suit specific climatic conditions and engineering requirements. The basic standard mix for the structual type consists of:

Cement	8 bags
Sand	20 c.f.
Vinfoam	32 liq. oz.
Accelerator	32 liq. oz.
Water	40 gallons

This mix yields one cubic yard of SHELTRON, with a density of 120 p.c.f. and a 28-day compressive strength of more than 3000 p.s.i.

Cement used to manufacture SHELTRON is of the Portland type and has to comply with the A.S.T.M. specification.

The fine aggregate is usually silica sand, graded between 40-60 meshes and complying with the standard requisites of being clean, free from organic and deleterious substances and sound.

The water is clean, potable and in such a proportion as to produce a pumpable mix for placing the material through a low pressure plaster gun, and to comply also with the requisites of density and strength without segregation of materials or water. The Vinfoam chemicals and

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[1]Vinfoam chemicals and an accelerator manufactured by the VIN-LOX Corporation are added to the mix.

accelerator are added to the mix as manufactured by the VIN-LOX Corporation. They are composed of selected resins and surface active agents for the purpose of stabilizing the chemical reaction and control the density of the concrete produced.

DENSITY, STRENGTH, AND REDUCTION IN WEIGHT

The density and strength of SHELTRON are controlled by proper mix design to meet the technical requirements within specified limits. SHELTRON can be manufactured with a density as low as 30 p.c.f. and as high as 120 p.c.f. For a 30 p.c.f. material, the minimum strength at 28 days is 300 p.s.i. For a 120 p.c.f. mix, the minimum strength is 3000 p.s.i. at the same age, without any special type of curing in both cases.

Figure No. 1 shows the relation between density and minimum strength. The material is manufactured at the job site with careful control of batching and mixing operations, to assure the quality required to meet the specific conditions of each job.

MODULUS OF ELASTICITY AND ALLOWABLE STRESSES

The Modulus of Elasticity of SHELTRON is a function of its density. For mixes between 50 and 120 p.c.f. density the longitudinal elastic modulus varies between 250,000 p.s.i. and 750,000 p.s.i. Figure No. 2 gives the relation of strength to modulus of elasticity. Allowable stresses for the design of reinforced concrete structures in SHELTRON are in accordance with the A.C.I. Standard Building Code Requirements for Reinforced Concrete. However, it is pertinent to point out that the ratio of tensile to compressive strength of cellular concrete is from 2 to 3 times higher than for normal concretes.

SHRINKAGE, THERMAL AND ACOUSTICAL PROPERTIES

Drying shrinkage of SHELTRON specimens prepared and tested in accordance with A.S.T.M. method C-157 modified as indicated in F.H.A. M603-2.2, gives values well below the established limit of 0.07.

Shrinkage is affected by many factors, the most important ones are the volume of cement and the volume of aggregates. In ordinary concretes, shrinkage is greater the larger the cement content and the smaller the volume of aggregates. In the case of SHELTRON, its expansion while plastic compensates in excess the plastic shrinkage, its quick setting property and low modulus of elasticity endow the concrete with enough early strength and large strains as to avoid noticeable cracking due to shrinkage.

The thermal properties: conductivity, diffusivity, specific heat and coefficient of expansion and contraction, have a definite bearing on dissipation and retention of heat, moisture condensation and changes in stresses and strains.

For normal concretes, common values of thermal conductivity vary from 0.5 to more than 1.0. SHELTRON of 100 p.c.f. density has an average thermal conductivity of less than 0.3 and for density of 120 p.c.f., SHELTRON's average value is less than 0.4. Figure No. 3 depicts the relation between density and thermal conductivity.

Concerning sound absorption and transmission, structural SHELTRON combines lightness, porosity and low stiffness to provide effective sound control.

FIREPROOFING AND FREEZING-THAWING CYCLES

SHELTRON can withstand 2000 degrees F for a period of 30 minutes, which results in fireproof construction, particularly since window and door frames can be built with SHELTRON without the use of any special form.

Finally, having a cellular structure, SHELTRON acts as an excellent air-entraining concrete and can be used in cold climates directly exposed to freezing and thawing. Although cellular concrete can absorb water, the rate of penetration is low as the larger pores will not be filled by suction. For this reason, SHELTRON has good resistance to frost, and can be used to advantage in the construction of exposed building walls in cold climates.

ECONOMY

SHELTRON ingredients are found in almost all countries and are usually inexpensive. It has all the lasting qualities of stone irrespective of climate. The complete elimination of formwork makes it adaptable to any shape and it can be furnished in different textures and colors to satisfty demanding aesthetic requirements.

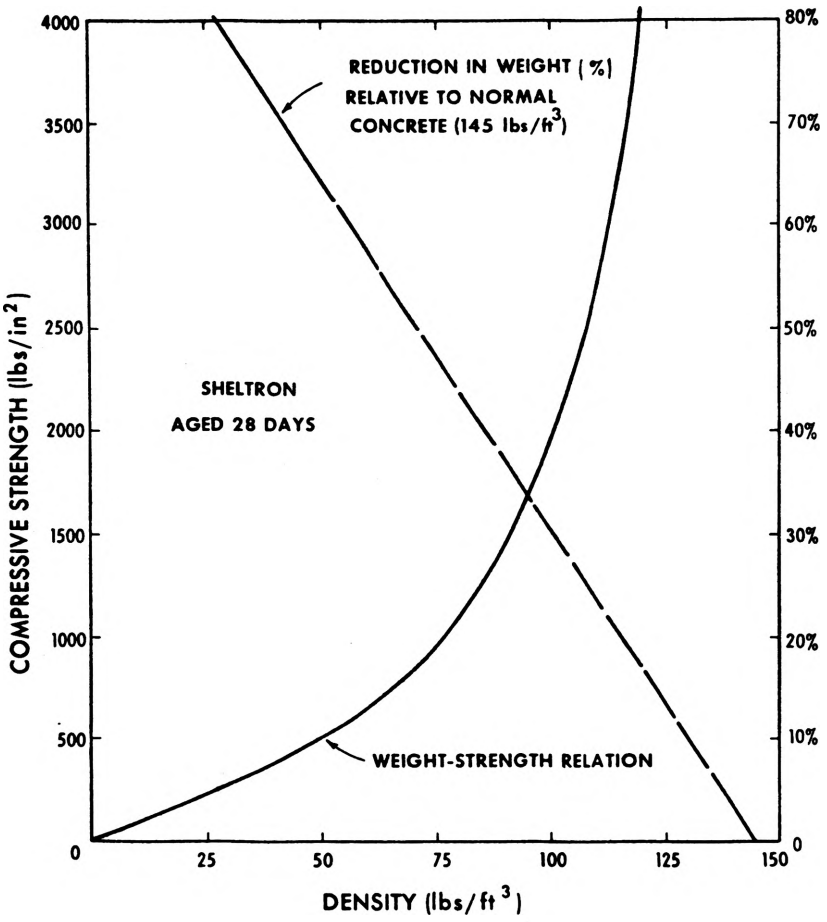
SHELTRON permits a departure from the limitations of cumbersome and costly straight-line design. In its place, new and daring concepts can become a reality. Technological developments in concrete shell engineering coupled with the SHELTRON construction system can free the designer from the many restraints inherent in construction with small scale building materials which properly belong to 19th Century technology.

SHELTRON is adaptable to economical construction of single and multiple family dwellings, and of commercial, industrial, and institutional buildings. The flexibility of the material makes it also ideal for the design and construction of exhibition pavilions, and park and amusement structures.

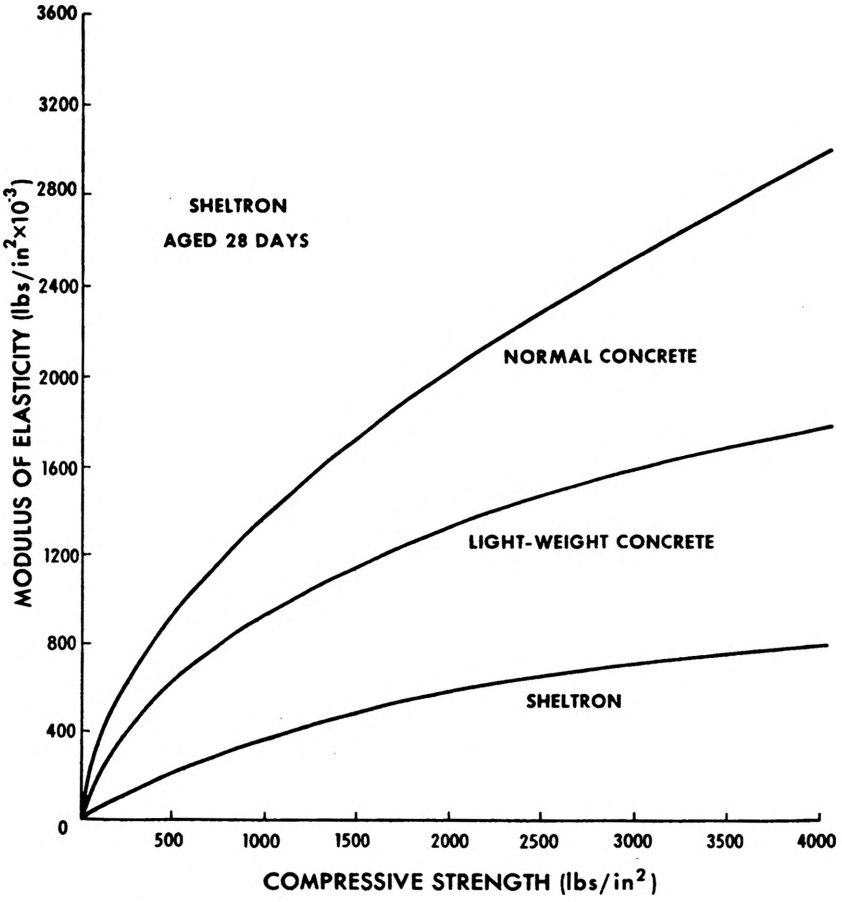
SHELTRON has many outstanding characteristics which make it a strong candidate for extensive use in the design and construction of standard and modular (pre-fabricated) low-cost housing units.

REFERENCES

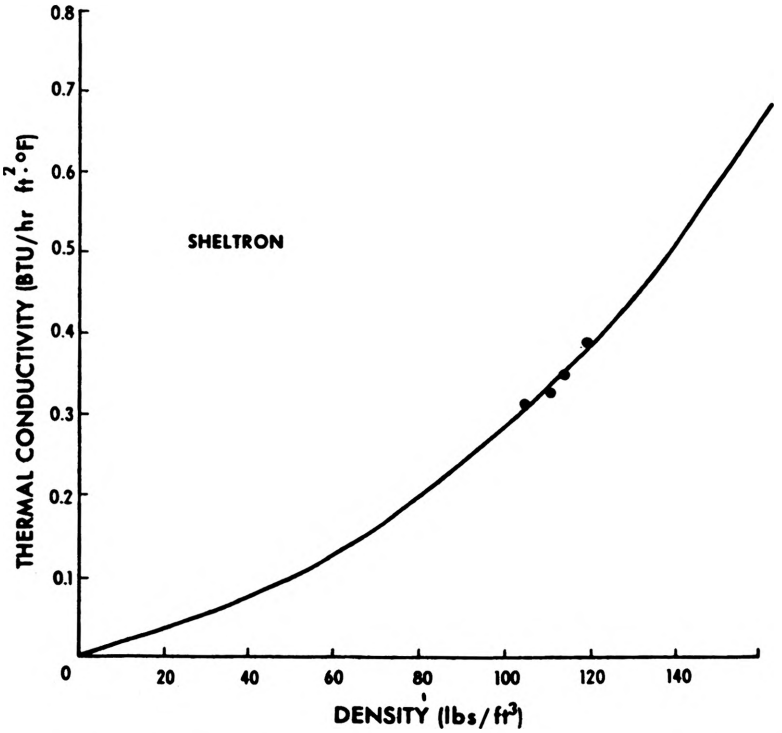
1. SACMAG and Assoc., Inc., "Report on VIN-LOX Concrete for VIN-LOX Corporation". October, 1968.
2. SLENT Computer Corporation brochure, "SHELTRON, A Construction System for the 70's". March, 1970



RELATION BETWEEN DENSITY AND MINIMUM STRENGTH
FIGURE 1



STRENGTH-MODULUS OF ELASTICITY RELATION
FIGURE 2



RELATION BETWEEN DENSITY AND THERMAL CONDUCTIVITY
FIGURE 3