CRACKING: CAUSES AND PREVENTION

To best understand the topic, some general information on **CEMENTITIOUS** products might be helpful.

Your regular everyday cement — used in concretes & masonry mortar — when mixed with water starts developing strength (& hardness) and continues to do so over an extended period of "curing" days. Cement Fondue — a specialized cement in certain industrial applications and occasionally in sculpture — sets rather quickly and develops most of its strength within 24 hrs. Both produce a hardened product, which is permanent and durable. Both however present inherent problems/restrictions to a sculptor w.r.t. pot-life, working consistency, set times, bonding, shrinkage, etc.
Your Gypsum-based cements (e.g. molding plaster, Hydrocal, Hydrostone) set almost immediately and achieve most of their strength within a few hrs. Although they possess some excellent properties — particularly for casting/molding — and have reduced shrinkage because of their inherent "expansive" property, they have one major drawback, namely the hardened product is **water-sensitive** an as such will deteriorate in an outdoor or wet environment.

All of the aforementioned "cementitious" products have relatively **good *compressive** strength but **very little *tensile strength.** It is this lack of adequate tensile strength that is the basic cause of cracking. Technically a crack or break occurs when a concentration of stress exceeds the maximum strain capacity of the material. This break (or deformation) is common to most materials — and is somewhat analogous to a similar situation in humans!
Therefore, the performance capability of a cementitious sculpture as it relates to crack-resistance depends primarily on:

1- Increasing the inherent tensile strength parameters of the cementitious product used,

2- Avoiding or eliminating possible stress build-up such as shrinkage stresses **by controlling water content and proper "curing".**

3- Increasing the strength and toughness of the whole by incorporating reinforcing elements to counter either inherent stresses or imposed stresses.

To expand further:
Re: item 1- Winterstone was developed as a new Sculpting/modeling medium. It is a complex multi-component formulation of several cements, mineral fillers, polymer, and other beneficent additives. It is a **balanced system** and requires only some mixing water. Besides having increased strength properties (both compressive & tensile) it has improved and controllable workability and setting times, increased bond and adhesion properties, reduced shrinkage potential, and reduced permeability and water absorption for increased freeze/thaw resistance — and hence **weather-resistant.**

Re: item 2- Generally, the build-up and completion of a WINTERSTONE sculpture takes several days — if not weeks, depending on size & shape — and is accordingly built-up in layers (Reference Technical Bulletins& Information sheets for critical "shell" thickness for various sizes). As with other cementitious products, when water is mixed in with the WINTERSTONE mix, only part of the water goes into chemical combination with the WINTERSTONE components, the amount **depending on the conditions and extent** of the curing period. The remainder is free to leave the matrix when exposed to a drying atmosphere. This tends to produce shrinkage stresses, the extent and rate of which depends on the amount of the original mix water and the curing conditions. The initial few hours after mixing and application are critical, as it is during this period that the **tensile** strength starts developing and requires water to continue development. Hence, premature drying-out should be avoided so as not to affect or slowdown the strengthening necessary to counter the increasing stresses. If the "fresh" surface dries out prematurely before sufficient internal resistance develops, **crack** potential is increased. Consequently, the surface should be **covered** as soon as possible and kept covered for at **least 24 hrs**, particularly for the final finishing layer. If the sculptor requires several hours of continued modeling before they can cover their piece with plastic sheathing or a bag, then they should **"fog-spray"** the exposed areas within 1 ½ -2 hours after application. The same basic "water-control" measures are applicable at other times during the modeling/sculpting process, namely:

a) Before applying a fresh layer over an underlying hardened surface, it should be sufficiently dampened with water (by spray or sponge) so that it does not "steal" by absorption water from the fresh mixture. This could detrimentally affect strength and adhesion along the interface between old & new.

b) Avoid over-working (by over-trowelling) the surface of the fresh mixture, as it tends to work-up some watery paste to the surface, which on drying may cause some "craze cracking". Smoothing of the surface, if desired, should be delayed some minutes until the surface has achieved some "set" but still has some plasticity and dampness. The material should be "set" enough to prevent migration of watery paste to the surface. The sculptor will have to monitor this timing as it depends on the amount of initial water content, and the ambient temperature and air conditions of the studio.
If this is the final layering, **damp-smoothing** at this time is best done with a rubber pad. Done properly, it will save countless hours of sanding the hardened surface to achieve the smoothness desired. If this surface is to be covered by a fresh layer the next day, or whenever, this would be the appropriate time to roughen the surface with a serrating tool. This procedure is recommended not only as a means of eliminating any bumps/irregularities in the surface, but also to provide a mechanical "toothing" bond for a future layer: a bonus to the inherent bonding capabilities of the WINTERSTONE itself.

It is important to follow recommendations regarding **mixing water and curing** as outlined in the Technical Bulletins. To do otherwise may result in a product with reduced strength and hardness, reduced weather resistance, and sensitivity to crack development. These negatives can be minimized, if not eliminated, using the following procedures: for crack control, some High Dispersant type A.R. chopped Fiberglas strand (1/8" or ¼")

should be incorporated into the mix as a regular procedure, in the amount of 1% (by wt) of WINTERSTONE. This will not only provide additional crack control, but also improve workability of the fresh mix.

(Re: item 3)

a) The stress/strain phenomenon resulting from external forces such as handling/shipping/erecting and/or heavy winds/public abuse of sculptures located outside can be eliminated by incorporating the appropriate reinforcing elements (*e.g.* rods/wire mesh) at possible stress points during the build-up of the sculpture. The need and type of such additional reinforcing depends solely on the particular design of the sculpture and where and how it is to be located.

b) If the completed sculpture is to be founded in an outdoor environment with extreme temperature fluctuations, whether day/night or seasonal, thermal stresses resulting from expansion/contraction phenomenon will require reinforcement at the appropriate location within the "shell" thickness. Since the greatest stress from thermal movement occurs in the surface skin of the sculpture, it is prudent to place mesh reinforcement **as close to the surface as possible** without affecting the sanding or surface refinements the sculptor intends to do. This additional mesh layer compliments the chopped strand mentioned above, which on its own may not be sufficient, particularly in extreme conditions.

- *Tensile Strength: resistance to being stretched — *e.g.* a rope holding up a weight.
- *Compressive Strength: resistance to compression — *e.g.* a pillar holding up a floor