

ONODA EXPAN

THE SHRINKAGE CONTROL ADMIXTURE FOR CONCRETE

WHAT IS THE PRODUCT?

ONODA EXPAN is a shrinkage control admixture manufactured by the Onoda Cement Company of Japan.

The product consists mainly of free lime, (Expansive CaO), and includes also Calcium Silicate and glass interstitial substance.

During manufacture, the combination of a specific high burning temperature with careful particle grading ensures a controlled rate of hydration of the product.

Upon hydration, Onoda Expan forms stable crystals of Calcium Hydroxide, $\text{Ca}(\text{OH})_2$, with a consequent predictable increase in volume.

Using a selected dosage of the product, this expansion can be utilised to balance the shrinkage characteristics of Portland Cement concrete. (OPC)

WHY USE SHRINKAGE CONTROL ADMIXTURES?

EXPAN admixture to concrete is used to reduce or eliminate the need for crack control joints. Joints create a continuing maintenance problem either due to breakdown of the joint sealant, or to mechanical breakdown of the joint edges when subjected to high impact loads.

Health regulations often demand a joint free floor for hygiene reasons.

ALL Concrete manufactured with Portland Cement or Portland cement blends will inevitably reduce in dimension, ie. SHRINK, given sufficient time.

The INEVITABLE consequence of this shrinkage will be the potential for the formation of CRACKS.



The conventional methods of crack control include:-

- 1) The use of preformed or 'control' joints
- 2) The use of post formed 'sawcut' joints
- 3) Combination of both

(These methods direct the shrinkage stresses to chosen positions)

- 4) The use of reinforcing placed in the upper section of the casting

(This method encourages the shrinkage strain into multiple fine cracks)

- 5) Combination of all above.

Note that with all these methods, joints are still an inevitable consequence.

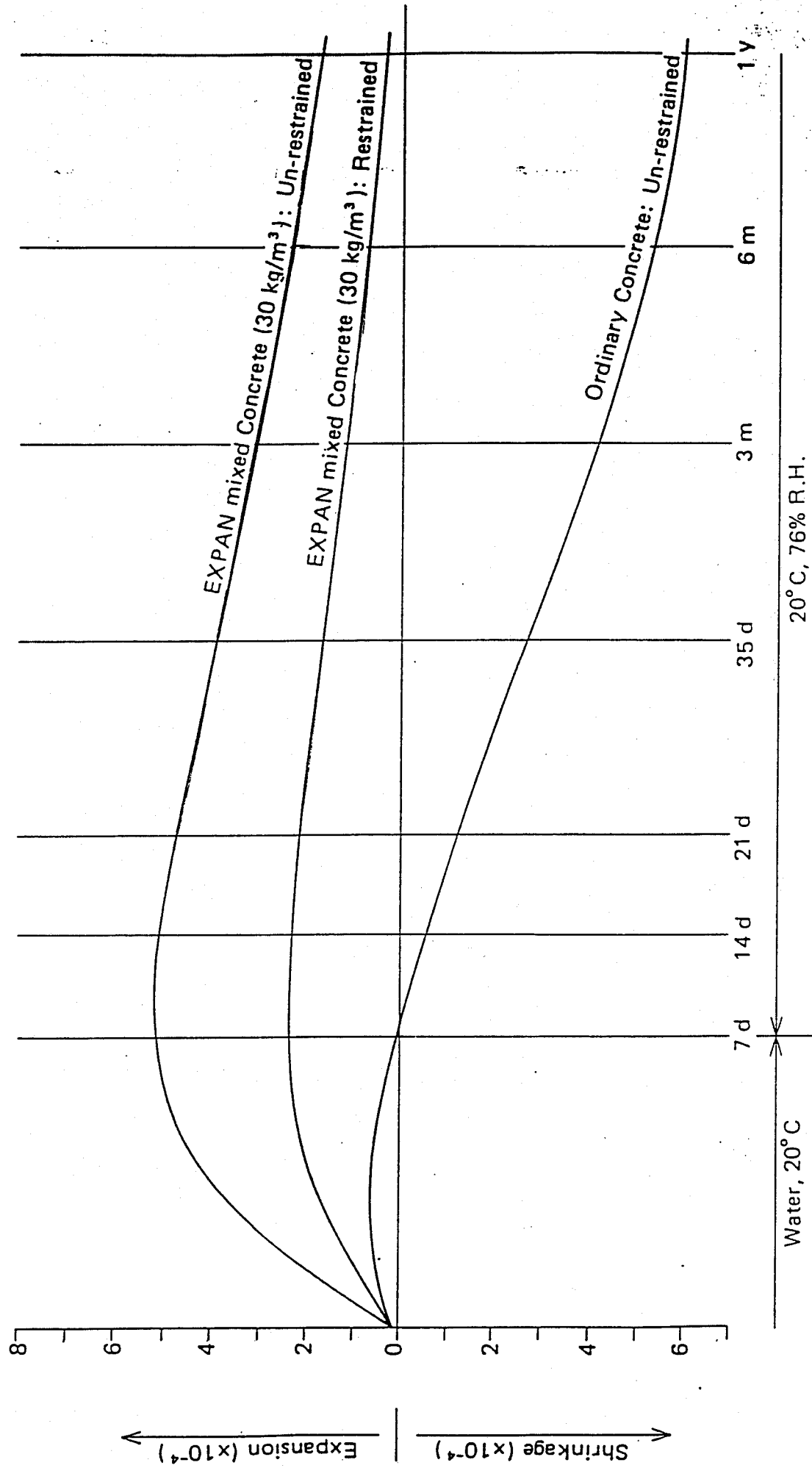
HOW DO SHRINKAGE CONTROL ADMIXTURES WORK?

Plate 1 illustrates typical shrinkage/expansion cycles over a twelve month period which can be anticipated when:-

- i) OPC cement concrete is used.
Shrinkage increases rapidly after 7 days, reaching a half life shrinkage 1.5 to 3 months
- ii) OPC + 30kg/m³ Expan is used (unrestrained)
Expansion peaks 3 to 7 days, and becoming neutralised by the OPC shrinkage factor reduces to a state of slight expansion after 12 months.
- iii) OPC + 30kg/m³ Expan is used (restrained)
Early expansion occurs up to 7 days but is considerably restrained in magnitude, while at 12 months the original cast dimension is achieved . ie. shrinkage nil. The energy stored in the restraint (reinforcing) during the expansive phase, has been dissipated in the OPC shrinkage phase.

(1) Comparison of Expansion Curves

Expansion and Shrinkage Characteristic Curve for Concrete with EXPAN 30 kg/m³ under restrained and unrestrained condition.





HOW DOES THE DOSE RATE OF EXPAN AFFECT EXPANSION & STRENGTH?

Plate 2 is a composite chart illustrating the effect of varying dose rates of EXPAN on strength and expansion in restrained and unrestrained conditions.

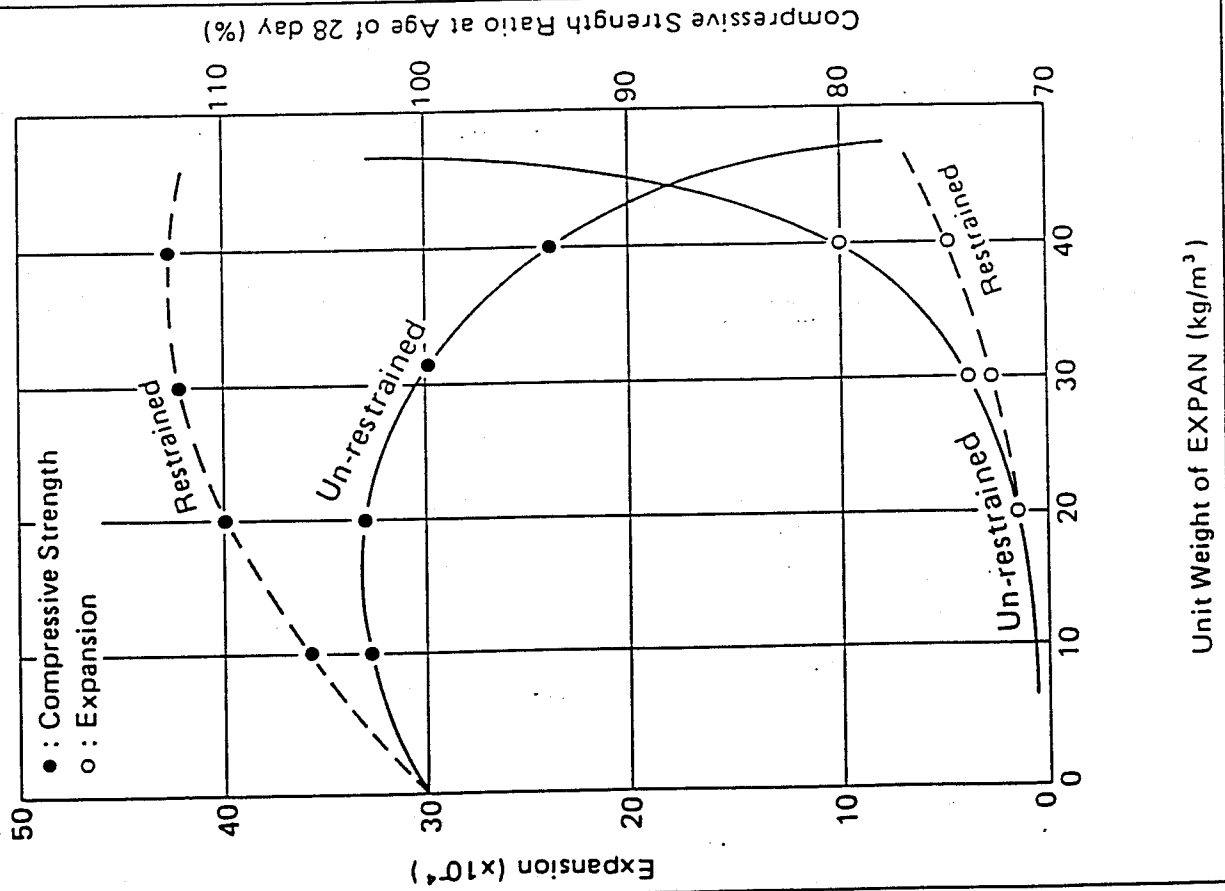
This chart provides an important tool for the floor designer for estimating the probable strain increase for a given volume of steel reinforcing, during the expansive phase.

For most crack control conditions a flat dose rate of 30 kg/m³ is recommended.

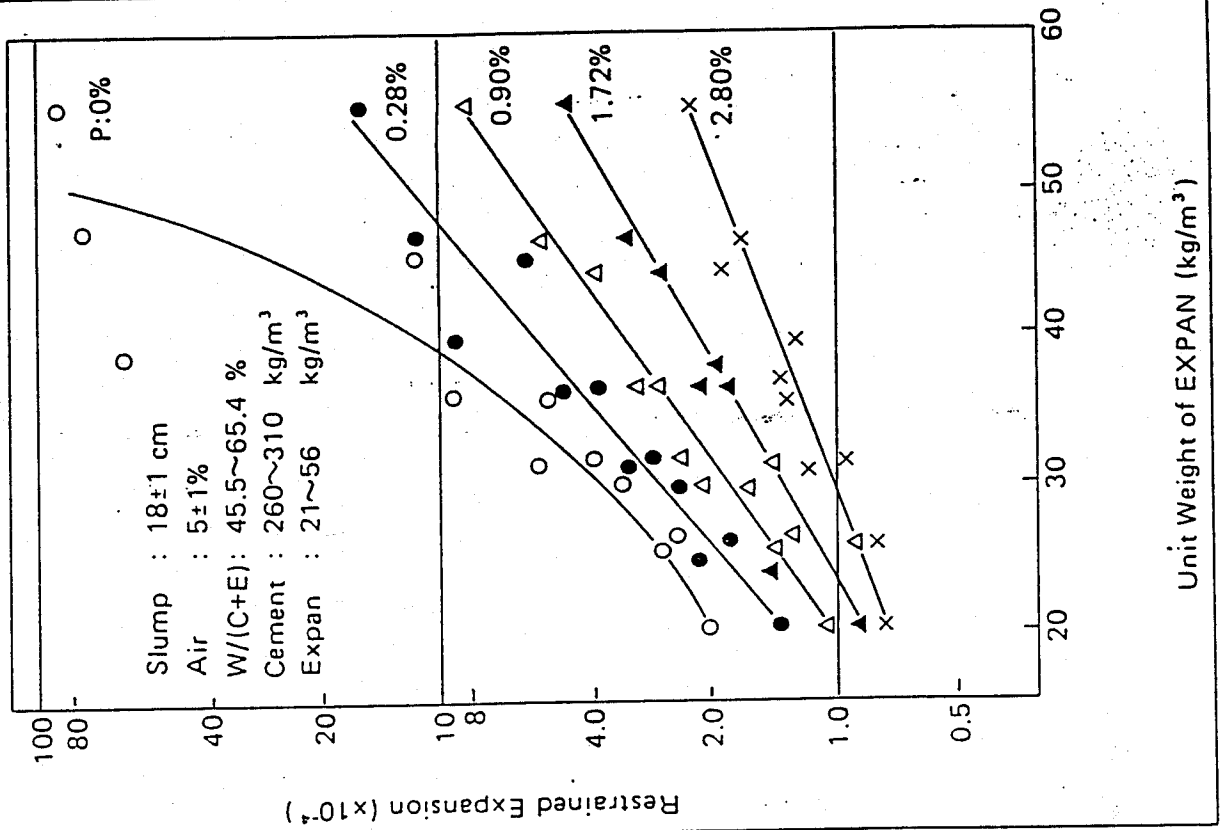
Plate 2 illustrates that this quantity can be used to replace the same mass of cement without loss of 28 day strength when used with cement contents of the order of 260 - 310kg/m³.

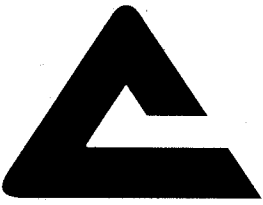
When EXPAN is used in high cement grouts, such as used for rock bolting, higher dose rates of the order of 40kg/m³ should be used dependent upon the anticipated increase in shrinkage factor for such mixes.

Relation between Amount of EXPAN and Compressive Strength or Expansion of Concrete



Relation between Amount of ONODA EXPAN, Steel Ratio and Restrained Expansion of Concrete





ARE THERE SPECIAL PRECAUTIONS REQUIRED WHEN USING EXPAN?

The precautions to be taken when using EXPAN are essentially the same as with any OPC cement based concrete.

However, as EXPAN is used as a 'value added' product, and client expectation is high. Consequently to achieve the best result careful planning and discipline of all operations is essential.

A. Manufacture (Batching)

- Mix designs as proven satisfactory for normal concrete may be used.
- EXPAN may either be substituted for the equivalent quantity of cement or simply added. The normal water demand will not be affected, nor the 'wet' concrete behaviour.
- The use of superplasticiser, as for normal concrete, will enhance performance and is recommended.
- 'House keeping' should be precise, particularly in regard to the accurate dosage of EXPAN.
- EXPAN is packaged in 20kg bags, and to avoid errors it is recommended that batch sizes are chosen which utilise full bags. (It is suggested that the bags used for each batch are marked with appropriate identification and retained for a period as proof of accuracy)
- Batchers should ensure the best method of distribution of EXPAN in the mix.

B. Floor Design

The design engineer must be aware of the dimensional changes anticipated, ie. expansion followed by OPC gel shrinkage, and design accordingly.

- Reinforcing concentrated in the upper third of depth section, and in the horizontal section balanced to achieve symmetrical stress in both length and width.
- Sub base provided with slip membrane to lower friction stresses.



- Reinforcing not be 'locked' to fixed points such as footings. (In large floors it is recommended that the 'jointless' floor be sited inside but not rigidly attached to a pre-poured perimeter 'floor', separated by a joint in which is placed a polystyrene strip, which is dissolved out when the concrete matures and replaced by a suitable joint sealer, thus forming a perimeter 'control' joint).

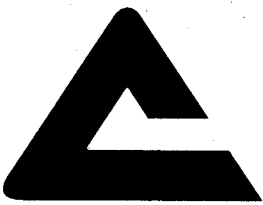
This perimeter floor is usually about 1 metre in width.

Similarly intrusions such as columns should be isolated from the floor by polystyrene strips.

C. *Curing:*

As for normal concrete, a curing regime should be applied as soon as practicable after concrete placement, and should be maintained for 3 to 7 days.

A simple method recommended is by water misting followed by covering with polythene sheet



CAN EXPAN ELIMINATE ALL CONCRETE CRACKING?

The answer is no - certainly not ALL types of cracking.

Strategies utilising EXPAN are primarily designed to overcome the shrinkage induced by the 'Gel' shrinkage inherent in the use of Portland cement.

The chemistry of the hydration of Portland cement is very complex.

In simplistic terms, Portland cement combines with water to form in the first instance, a 'Gel'. As the hydration reaction proceeds, heat is evolved and concentrated gel solution proceeds to convert to the crystalline complex we recognise as mortar.

Depending upon the availability of water for reaction this hydration process may continue for twelve months or longer. If there is insufficient water in the system, the reaction may cease, but may be reinstated at a later date by water addition.

During the process of gel conversion a loss of volume inevitably occurs, ie. the mortar 'shrinks', typically reaching a 'half life' in two to three months and in practical terms reaching completion in twelve months. During this period cracks either controlled or uncontrolled, are inevitable.

EXPAN has been specifically designed to control GEL shrinkage.

WHAT IS THE NATURE OF OTHER FORMS OF SHRINKAGE AND ARE THEY CONTROLLABLE?

Yes! There are two other main forms of concrete shrinkage which may occur - both are operator controllable - both tend to occur within the first 48 hours of concrete life.

1) Plastic shrinkage

This is a consequence of loss of volume of the freshly placed concrete due to water evaporation. The rate of evaporation is essentially a function of climatic conditions pertaining at the time and is influenced by a combination of temperature, humidity and wind speed. Precautions include placing under cover, wind breaks, and slowing evaporation by spraying with aliphatic alcohol such as 'Confilm'.



2) *Thermal differential*

This is caused by differential temperatures such as hydration heat build up in the concrete mass accompanied by surface 'chill' as a consequence of moisture evaporation (latent heat effect) or climatic conditions, and is possibly one of the most common faults observed.

However, this can usually be overcome by water 'misting' of the surface immediately after finishing and covering with polythene sheet. This sheet should be retained in position for 3 - 5 days.

It is important to note that cracks occurring due to these causes will continue to extend during the subsequent Gel shrinkage phase unless EXPAN is used.

IS EXPAN SUPERIOR TO OTHER PROPRIETARY SHRINKAGE CONTROL ADMIXTURES?

Yes! EXPAN has important advantages when compared to SCA's based upon Ettringite formation. As the primary chemical reaction of EXPAN is based upon the hydration of Calcium Oxide, CaO, by water to form Calcium Hydroxide, Ca(OH)₂, ie. one molecule water per molecule CaO, there is no excessive water demand to produce workability. In practice there is no change in ordinary wet concrete characteristics when EXPAN is used.

In comparison, other SCA's based upon Calcium sulfoaluminate, (3CaO.3Al₂O₃.CaSO₄), react with water to form needle like 'Ettringite' crystals by combination with up to 32 molecules of water per molecule. (3CaO.3Al₂O₃, CaSO₄.32H₂O)

Thus concrete containing this type of admixture should not be put in a position of risk of 'water starvation' as in the case of say, a long delivery time, or early concrete 'stiffening' may occur.

A further consequence of this difference in chemistry is in the area of heat stability.

In the case of EXPAN the water component of the Ca(OH)₂ does not become released until a temperature of 580 degrees C is attained, while the water of crystallisation in the ettringite begins to release at temperatures in excess of 80 degrees C.

Dosage recommended for EXPAN is 30kg/m³.

Dosage recommended for the alternative product is based upon 11% of cement content. Under these conditions the expansion cycles are effectively the same, but the 11% dosage by replacement of the alternative product will cause a small loss of compressive strength..