Chemical Admixtures Uses for Concrete in Kurdistan

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DECEMBER 2023

Historical review:

Admixtures in concrete was developed along last decades, According to most information available:

- Some admixtures like Alkaline Silicates start to be used in the beginning of 20th century.

- In 1930s-decade, normal plasticizers start to be used as normal water reducers and workability enhancer.

- In 1980s and 1990s, High performance concrete and Self compacting concrete (SCC) have been developed which requires high range water reducing admixtures (HRWRA) to achieve the special performance of HPC and SCC.

- Chemical admixtures in Kurdistan mainly start to be used after 2003, and start to be available in the market after 2007 as a result of infra structure and building construction development.

  During this period, Chemical admixtures was only imported from neighbor countries mainly from Turkey and later from Jordan and UAE.

  Some construction companies were hesitated to use the admixtures and many companies were not accepting concrete with admixtures because they were thinking that concrete suppliers was using the admixtures to only reduce the cement content in the concrete mixtures as a theft of cement content.

  After 2010, this tendency starts to be changed partially by time until 2012, when clients and Engineers start to understand by practice the positive impact of using chemical admixtures in concrete.

  Even though, until now, some concrete producers are not using chemical admixtures.

Chemical Admixture in the Market:

Chemical admixtures in Iraq and Kurdistan market are available from two main sources:

1- Locally produced

1-1 For commercial and political reasons, some companies which was importing admixtures either as distributers, or from their production facilities and plants outside of Iraq in neighboring countries. This have been done to:

1-1-1 Secure the availability of admixtures locally to be supplied upon requests in short lead time.

2-1-1 Eliminate periodically shortage of admixtures because of periodically borders closure for different reasons.

3-1-1 Reducing cost of admixtures as they will only need to import the raw-materials which represent only 20-35 % of final product, the remaining material for production is the water which is cheaper to be used from local source.

4-1-1 also, lower employees' rate which also will reduce the cost of final products.

2- Imported From Origin Producer Countries:

Many trading companies are importing admixtures from different countries like Turkey, Jordan, UAE and limited sources from Europe and China.

Local admixtures companies:

- Many admixture companies have been established in Iraq, many of those companies are located in Kurdistan region mainly in Baghdad, Basra, Sulaymaniya and Erbil.
- Local admixture companies are either international, regional or local companies.

Example of admixture companies which have a production facility in Iraq:

- BASF, international company, only importing mainly from Jordan and Turkey.
- SIKA and FOSROC, International companies producing locally and importing some of special products from Jordan, Turkey and UAE.
- CHRYSO, International Company.
- DCP, Regional Company.
- CONMIX, Regional Company based in Dubai.
- SHVA, HMA and LYDA: Local Companies. Supported by regional companies.
- Some concrete companies establish their own admixture production facilities mainly for their need.

Classification of Admixtures:

1- According to ASTM C494

1-1 Type A:

1-1-1 Low-range normal low water reducer (Reducing water up to 5%).

1-1-2 Mid-range water reducing (Reducing water 5-10%).

1-2 High Range Water Reducing Admixtures (HRWRA):

1-2-1 Type F: HRWRA without retarder or accelerator.
1-2-2 Type G: HRWRA with retarder.
1-2-3 Type E: HRWRA with accelerator, this type can be used in cold weather to accelerate setting of concrete and prevent from freezing.

1-3 Type B: Retarder for setting time delay.

1-3-1 pure retarders, need to give high attention carefully added to

Concrete can be used in hot weather and for slip for concrete.

Range of dosage usually very low and can be less than 0.4% of cement.

1-4 Type C: Accelerator for accelerating setting time.

1-4-1 Calcium Chloride (Not allowed to use in reinforced concrete).

1-4-2 Calcium Format

1-4-3 Triethanolamine

1-4-4 a unique hardening accelerators are produced by some companies based on essential component of the “Crystal speed hardening concept”.

1-5 Type D: Water Reducer and Retarder for setting time delay.

1-5-1 Low to mid-range, usually using in hot weather for setting delay.

1-6 Type S: Covers variable specific performance admixtures:

1-6-1 Viscosity modifying admixtures (VMA) for rheology control and:
- Anti-wash admixture, ASR,
- Anti-Shrinkage,
- Mortars stabilizers,
- Cement reaction healing.
- Surface retarders for exposed concrete.
- Admixtures for filling concrete.

2- According to ASTM C 260:

2-1 Air entrained Admixture

3- According to ASTM C 1017:

3-1 For producing “Flow Concrete”

4- According to ASTM C979:

4-1 For pigment used in integrally colored concrete.

5- ASTM D98:

5-1 Standard specification for Calcium Chloride.

6- Waterproof and watertight admixtures

6-1 Hydrophobic-Pore blocking system
6-2 Crystalline system

7- Corrosion Inhibitors: ASTM C1582

7-1 It is recommended for all steel-reinforced, post-tensioned and pre- stressed strands, de-icing salts and in marine environment concrete.

7-2 Calcium Nitrite
(Make sure it is not Calcium or Sodium nitrate).
Comply with ASTM C1582.
Neutral set admixture.

7-3 MCI 2005:

- It is a special organic corrosion inhibitor contains a blind of Amine salts,
- It is considered “Ambiodic” means meaning it protects both anodic and cathodic areas within a corrosion cell.
- Slightly retard the setting time of concrete compared to control mix.

8- According to EN 934

Admixtures imported from Turkey are produced according to EN standards. Some how, it is almost complied with ASTM standards.

Main Effective components of admixtures:

- Legno-sulphonate
- Sulphonated lignin.
- Sulphonated melamine formaldehyde SMF. Rarely used now.
- Sulphonated naphthalene formaldehyde SNF
- Polycarboxylate Ether PCE (Acids or polymers), Low-range, Mid-Range and High-Range.

Note: Blue-Methylene Test (BMT) is recommended to calculate the percent of clay and / or active clay in sand, this is because the performance of admixtures is highly affected negatively by increasing Blue-Methylene content.

Important Information should be known about admixtures:

- Request the TDS and SDS of each product from the supplier, read, understand and ask questions.
- Focus on:
- Base effective component,
- S.G, Solid content,
- PH.
- Range of dosage,
- Compatibility with cementitious materials,
- Limitation of usage and over dose impact on concrete performance.
- Production and Expiration dates once receiving any order.
- Storage condition, min. and max. ambient temperature, away from direct sun light,
- Discuss with supplier's technical Engineer.
- Ask who is using the product recommended by supplier.
- Compatibility with raw materials in different regions
  Some types of admixtures may not be compatible with cements and or sand you may use.
- Unit price should be clearly specified is it per liter or per kg. Low unit price doesn't mean cheaper product, what is important is the impact on the cost of the mix recipe that match your requirements and concrete performance specified by clients.
- Implement trials as much as possible to understand the performance and compatibility of admixture for your needs.

What HRWRA, can do for concrete:

- First, HRWRA should be able to increase concrete slump from slump ranging (80-120mm) to minimum of (200mm) when using a dosage approximate to average of the dosage range of admixture recommended by manufacturer.
- Increasing slump while keeping mixing water at same value.
- Reducing mixing water while keeping slump and increasing strength.
- Reducing cement content as impact of reducing mixing water While keeping slump and strength.

Note: Some special admixtures which can be used in Ultra high performance concrete UHPC can reduce the W/C ratio to less than 0.18 down to 0.12
It is commonly used in concrete where 80 Mpa up to 150 Mpa cylinder strength is specified.

What is the Importance of Air Entrained Admixture in Concrete?

- It is requested by concrete codes and specification that when concrete maybe exposed to freezing and thawing cycles, air entrained admixture should be added to the concrete to increase the air content to average of 6% with a tolerance of ± 1.5% (a range of 4.5-7.5%).

- It is very important in all Kurdistan Region to use air entrained admixture in all floors, bath-ways and all concrete like exterior walls, pavements and airport run-ways exposed to cycles freezing and thawing.

- Unfortunately, this is not the case which causes a lot of concrete damages and cracking in concrete.

- Take into account, that increasing 1% of 1ir entrained in concrete will decrease strength by average of 5%. Mix should be modified to compensate the strength reduction.

What Retarders can do for concrete?

- Extending setting time of concrete mainly in hot summer and for Mass concrete like raft foundations and RCC concrete in dams to prevent causing cold joints and dramatically increasing hydration temperature of concrete after cast.

- Using retarders in concrete for slip-form system like in chimney, Cement factory storage silos and similar applications.

- Using retarder in concrete for diaphragm retaining walls where slump retention may need to be more than 5 hours.

- For long-transportation of concrete, it is recommended to use a special reaction healing (Stabilizer) admixtures if transportation or casting time may be expected to reach 8 or 10 hours. The product is includes two components, A & B.
  This product have been used in Iraq recently for specific project, concrete have been cast after 7-8 hours.
  Also, it can be used to supply concrete for sites where streets may be closed during heavy traffic and peak time. Truck mixers can wait on site until elements become ready for cast, once it is ready, Component B is added to the concrete to stop the effect of component A.

Best Practice of admixture management :

From our study, related to good practices of using admixtures in concrete plants and construction sites, we can summarize as following:

Best Practices & Recommendations:

- Install tanks for admixtures with pumps and hoses from each tank to the weighing balance tank at plant, capacity should be enough to maintain a minimum stock of 5,000-10,000 liters.

- Installing 1 tank of 10,000 liters and second tank of 5000 liters is highly recommended to better managing the stock for each type of admixtures. This is depending on daily production and lead time for delivery of orders from supplier's stores. Using IBC tanks of 1000 liters capacity will need more space of land for admixture storage, also a loss of admixture may be happened.

- Add circulation pump for each tank to prevent sedimentation of admixtures.

- In Kurdistan Region, it is recommended to insulate the tanks to prevent Admixture from freezing in cold weather.

- Increase mixing time when using PCE admixtures versus SNF and or legno-sulphonate admixtures to ensure reaching to full admixture performance giving the actual slump/slump flow at the plant.

- Different types of admixtures should not come in touch before mixing. Setting of time-lag between adding different types of admixtures should be carefully planned during production to prevent negative impact on admixtures performance. Follow manufacturer recommendations.

- Admixtures weighing balances should works separately to make sure no admixtures will be mixed, as above, time -lag should be set-up in production process.

- Testing compatibility of admixture with different types of cements expected to be used in the plant should be done to maintain back-up mixes maintaining the right admixture with each type of cement if needed.

- According to ASTM C94/94M, it is allowed to increase low slump/slump flow at site by adding water, it is safer to send a gallon of admixture with each truck-mixer to use for increasing slump at site if needed.

- Measuring transparent hose showing scale level of admixture stock should be added to the tanks to follow stock, so no sudden shortage may happen that can stop the production.

- Each admixture type tank should be labeled to prevent from any mixing of admixture during filling admixtures tanks by supplier.

- Make sure that you have the basic tools for testing S.G of admixture at arrival before receiving or confirming to the supplier to empty in site tanks or un-loading.

- Make sure that IBC tanks are fully empty before leaving the site and or use weigh-bridge to weight the net quantity received.

  Average of 50 liters can be lost because of retained admixture in IBC which can’t be pumped in plant tanks which can represent 5% losses.

- For better understanding admixture that may needed to be added to increase low slump to the required slump at site, make records of admixture additions at site or at plant to modify low slump so you can use in training and explanation to your team to help them how much they may need to add.

Trouble-shooting:

1- Can concrete strength at 7 days be more than strength at 28 days?

The answer is **No**, if they both are from the same mixture, 7 days concrete strength can't be more than 28 days strength.

All practical claims coming from sites or projects, end with one fact that the case was caused by other causes than cement strength development.

Mostly a non-proper sampling, preparation of cubes or cylinder, mixing different groups of specimens or samples from different truck-mixers, non-proper curing conditions, compression machine calibration, rate of loading and other causes have been founded as a cause of getting lower strength of concrete in 28 days comparing to 7 days strength.

According to one of the concrete experts, explain that concrete strength development is like human being, start as a baby, grow-up until being old man, he may die but he can't get younger.

Firstly, we need to know why the concrete get strong.
Mainly it's because of the concrete hydration reaction.

There are about 4 main reactions in concrete hydration process.

1- Tricalcium silicate hydration.
   $3CaO \cdot SiO_2 + nH_2O = xCaO \cdot SiO_2 \cdot yH_2O + (3-x)\ Ca(OH)_2$

2- Dicalcium silicate hydration.
   $2CaO \cdot SiO_2 + nH_2O = xCaO \cdot SiO_2 \cdot yH_2O + (2-x)\ Ca\ is(OH)_2$

3- Tricalcium aluminate.
   $3CaO \cdot Al_2O_3 + 3(CaSO_4 \cdot 2H_2O) + 26H_2O = 3CaO \cdot Al_2O_3 \cdot 3CaSO_4.32H_2O$

4- Iron phase solid solution hydration.
   $4CaO \cdot Al_2O_3 \cdot Fe_2O_3(C_4AF) + 4CH + 22H = 2C_4(A, F)H_{13}$

As time goes on, reaction get complicated and concrete get stronger. So, we get the answer above.

2- Why concrete floors cast behave like bread dough mainly happened in summer?

The answer is in most cases, it happened because of quick drying of concrete surface while bottom concrete layer is still wet, surface drying usually happened because of high rate of evaporation caused by high ambient temperature, low to very low RH, high wend speed and low rate of bleeding, this is also can cause early shrinkage cracking which is commonly happened in horizontal concrete elements like raft foundations, floors and slabs.

To prevent this, rate of evaporation ROE of should be calculated. The rules to deal with the results are:

- If ROE is less than 0.5 kg/m2/h, no shrinkage cracking will happen.
- If ROE is between 0.5-1 kg/m2/h, some precautions should be implemented to reduce ROE.
- If ROE is higher than 1.0 kg/m2/h, it is recommended to delay cast, other-wise it is too difficult to prevent shrinkage cracks and can be catastrophic.

3- Why concrete slump may not be consistent at production time?

The answer is usually because concrete plant's operators are not properly using the moisture content of materials mainly in sand,

High variation in sand moisture content is because of using washed river sand which contains variable moisture content,

Also, loader drivers are not properly take sand from the right height above the ground to prevent loading sand with high moisture content sedimented to bottom of sand stock then loading from higher layer of sand with lower moisture content.

The other cause may be sedimentation of admixture effective solids because circulation pump is not commonly used in plants.

4- How to choose the write admixture and dosage for different types of cement?

- The answer is first by doing trials for standard concrete based on strength.
- Use Marsh cone and or micro-concrete to compare different performance.
- Availability, consistency and economy should be the main KPI to decide.
- Short-list the best admixtures based on compatibility the main cement You prefer or plan to use and back-up cement.
- Make additional trials based on initial results to decide the best range of dosage to use.
- Keep following-up the performance through quality records for additional optimization both for better performance and economy.

5- How to calculate effective age of concrete in cold weather

General:

Specifically, for KRG, and because of too cold weather during winter time, And as we all know that cement reaction need minimum ambient temperature to be developed properly an in accepted rate. For this, a curing condition have been specified in all standards.

For specific needs, when early strength of concrete elements, or actual concrete strength under same site curing conditions including ambient temperature is important to monitor and control.

5-1 cold weather conditions affecting strength development of concrete elements.

The definition of cold weather which is more critical in strength development is: The cold day is the day in which the means that ambient temperature in that day is less than 15 C° or the lower/ minimum temperature during that day is less than 10 C°.

Most studies, researches and some codes standards which may be slightly different between country to country, shows that in cold weather we should calculate effective age of concrete in days as following:

5-1-1 According to PS 282-1999 :

5-1-1-1 Each cold day after cast concrete in which the mean ambient temperature is between10 C° and 15 C° or if the minimum ambient temperature is 0 C°-10 C°, we should assume this day as a half day in concrete age for compressive strength test and forms or shuttering de-molding.

5-1-1-2 Each cold day after cast concrete in which the mean ambient temperature is less than 4 C°, each of those days should not be calculated in the age of concrete.

5-2 According to Iraqi code 304-2023, item 3-11, page 12/3, temperature should be minimum 10 C° after cast for minimum of 7 days or 3 days if accelerated curing is implemented.

5-2-1 Site curing conditions can be used to check the actual strength for concrete cast in structure like in Tunnel Form construction system.

5-2-2 Minimum strength for samples cured on site should achieve 85% of standard lab curing conditions.

Recommendation for a compatibility study for concrete produces:

Admixture producers may do the same study to allocate and positioning their products compatibility with cements in the market and with other raw materials in concrete mainly sand.

1- Choose the raw materials to be used in the mixes i.e., Sand and gravel in the region or governorate.
2- Chose minimum 2 types of cements, main and back-up cement you may use.
3- Decide the class of concrete which represent the best sale in the market or in your plant. Prepare control mix without admixtures.
It is important to define the slump class preferred and or specified in the market. The control mix slump should be in the range of 80-120 mm without admixture.
4- Choose 4-6 companies to recommend admixture from their products list they believe should work for your region.
You can use your ex-experience and practice to decide manufacturing company and product.
Unit price of each product should be agreed with supplier.
5- Collect 2 samples for each product from each supplier.
Each should be a minimum of 25 liters drum, well-sealed by manufacture.
Use one drum for trials and keep the second as back-up as reference.
6- Plan and define trials dates, test to be implemented like:

6-1 Slump and concrete temperature measured at initial at 5,30, 60, 90 and 90 minutes.

6-2 Fresh density and air content at 90 minutes.
6-3 Prepare cubes for testing initial and final setting time.

It is recommended to make 2 cubes for each mix.

6-4 Sampling cubes to be tested for 24 hours, 3 days, 7 days and 28 days.
14 and 56 days can be added to ages of compression strength tests.
For each age, prepare minimum 3 cubes for compression strength tests.
Recommended to repeat each trial 2 times to get the average better represent the performance results.
7- Do one mix with different admixture as a start to understand approximate performance of each admixture with each cement type.

Use supplier recommendation of dosage in TDS, or your previous experience with admixtures.You can use Marsh cone and or micro concrete method to decide the best dosage and admixture for different cement type.

8- Arrange results in graphs and tables for easier comparison.
9- Decide first option and back-up option for the mix.
10- Report the findings, prepare a presentation to present and discuss with your team and manager.

Use the results as a reference to develop and test the range of products mixes you may use in the plant and or for projects.

Finally, I want to express my gratitude to every person whom helped me or taught me even a single word to become the engineer that I am today, hope that this research will be useful and helpful for every engineer that wants to work in this field.

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December 2023