5.13 MASS CONCRETE PREDICTION NOMOGRAM

5.13.1 GENERAL

This BDM provides information and guidance on concrete structure elements identified as mass concrete, which should be designated as such on the Memo to Structure Office Engineer.

5.13.2 BACKGROUND

ACI 207.1[1] defines mass concrete as “any volume of concrete with dimensions large enough to require that measures be taken to cope with the generation of heat from hydration of the cement and attendant volume change to minimize cracking.”

Higher curing temperatures increase the risk of delayed ettringite formation, self-desiccation, and cracks due to thermal stress. All three issues impact the long-term durability of concrete. Delayed ettringite formation (DEF) is an expansive reaction that causes concrete deterioration like alkali-silica reaction. Self-desiccation, or self-drying, impedes the hydration process, increases permeability and shrinkage, and lowers the ultimate strength of the concrete. Thermal cracks, as with any cracks, increase water intrusion thus shortening the time to corrosion initiation in the reinforcing steel.

The four most significant factors affecting the peak temperature in a concrete element during the curing period are the amount of cement in the concrete, the size of the element, the temperature of the concrete at the time of discharge, and the ambient temperature. With reasonable estimates of these four variables, concrete elements that are likely to require additional measures to cope with the generation of heat from hydration can be identified.

The Mass Concrete Prediction Nomogram uses reasonable estimates of the four most significant factors affecting temperature. The effects of these four factors are accounted for in the evaluation of concrete elements. The output establishes whether a concrete element is to be identified as mass concrete in the contract.

An example is provided in Figure 5.13.2.1 that demonstrates how the nomogram is used and a clean copy is provided in Figure 5.13.2.2.

5.13.3 ASSUMPTIONS

The nomogram assumes that 100% of the cementitious material behaves as Type II portland cement. This assumption is made because the exact cementitious constituents are not known at the design phase and some commonly used SCMs cannot be relied upon to reduce peak temperature.

The specified 28 day compressive strength is related to the cementitious content used to calculate the heat generation by an assuming 300 lb/cy of water and a water to cement ratio provided in *Design & Control of Concrete Mixtures* [5] that corresponds to the specified strength.

The nomogram applies to normal weight concrete.

The concrete element is assumed to be cast in forms above ground, either supported by falsework or the ground surface.

The nomogram does not apply to Rapid Strength Concrete, precast concrete, lightweight concrete, or CIDH piles. For Rapid Strength Concrete, see "BDM 5.12 - Rapid Strength Concrete." [3] Both precast concrete and CIDH pile concrete have Standard Specification [2] provisions that address requirements for controlling concrete temperatures during hydration.

The average ambient temperatures provided in the table on the nomogram represent the average peak average ambient temperatures' of their respective county as reported by https://weatherspark.com [4]. These values represent a reasonable estimated minimum input. Due to intra-county variation, the designer should verify the average ambient temperature value if project specific location information is available.

The plastic concrete temperature at the time of discharge into the forms is assumed to be the average ambient temperature, except that it is not to exceed 90 degrees F, which is the Standard Specifications [2] maximum allowable concrete delivery temperature.

5.13.4 REFERENCES

1. American Concrete Institute. (2005). ACI 207 Section1-05 Guide to Mass Concrete. Farmington Hills, MI.

2. Caltrans. (2018). Standard Specifications, California Department of Transportation, Sacramento, CA.

3. Caltrans. (2021). Bridge Design Memos 5.12 Rapid Strength Concrete, California Department of Transportation, Sacramento, CA.

4. Cedar Lake Ventures, Inc. (2020). "Average weather in…https://weatherspark.com

5. Portland Cement Association. (2003). Design and Control of Concrete Mixtures, Skokie, IL.

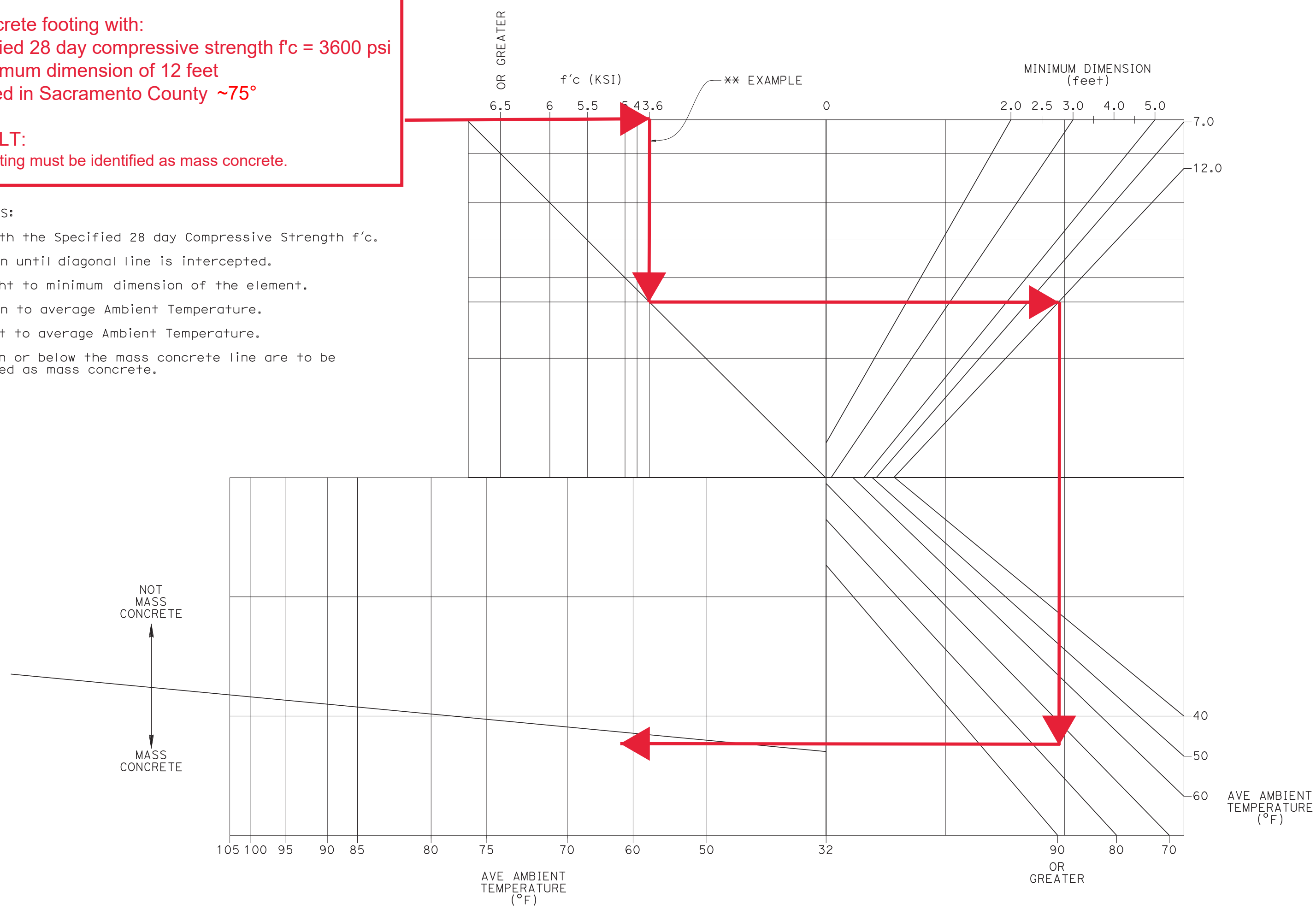
**EXAMPLE:

A concrete footing with:
Specified 28 day compressive strength f'c = 3600 psi
A minimum dimension of 12 feet
Located in Sacramento County ~75°

RESULT:
The footing must be identified as mass concrete.

INSTRUCTIONS:

1. Enter with the Specified 28 day Compressive Strength f'c.
2. Move down until diagonal line is intercepted.
3. Move right to minimum dimension of the element.
4. Move down to average Ambient Temperature.
5. Move left to average Ambient Temperature.
6. Points on or below the mass concrete line are to be identified as mass concrete.



COUNTY	AVERAGE AMBIENT (°F)
Alameda	70
Alpine	55
Amador	75
Butte	70
Calaveras	70
Colusa	70
Contra Costa	75
Del Norte	70
Fresno	80
Glenn	75
Humboldt	70
Imperial	90
Inyo	95
Kern	95
Kings	80
Lake	70
Lassen	55
Los Angeles	75
Madera	70
Marin	65
Mariposa	75
Mendocino	70
Merced	75
Modoc	60
Mono	60
Monterey	65
Napa	70
Nevada	70
Orange	75
Placer	75
Plumas	60
Riverside	75
Sacramento	75
San Benito	70
San Bernardino	80
San Diego	75
San Francisco	65
San Joaquin	75
San Luis Obispo	70
San Mateo	65
Santa Barbara	70
Santa Clara	70
Santa Cruz	65
Shasta	55
Sierra	55
Siskiyou	65
Solano	75
Sonoma	65
Stanislaus	75
Sutter	75
Tehama	80
Trinity	60
Tulare	85
Tuolumne	65
Ventura	70
Yolo	75
Yuba	75

Figure 5.13.2.1 Mass Concrete Prediction Nomogram - Example

INSTRUCTIONS:

1. Enter with the Specified 28 day Compressive Strength f'c.
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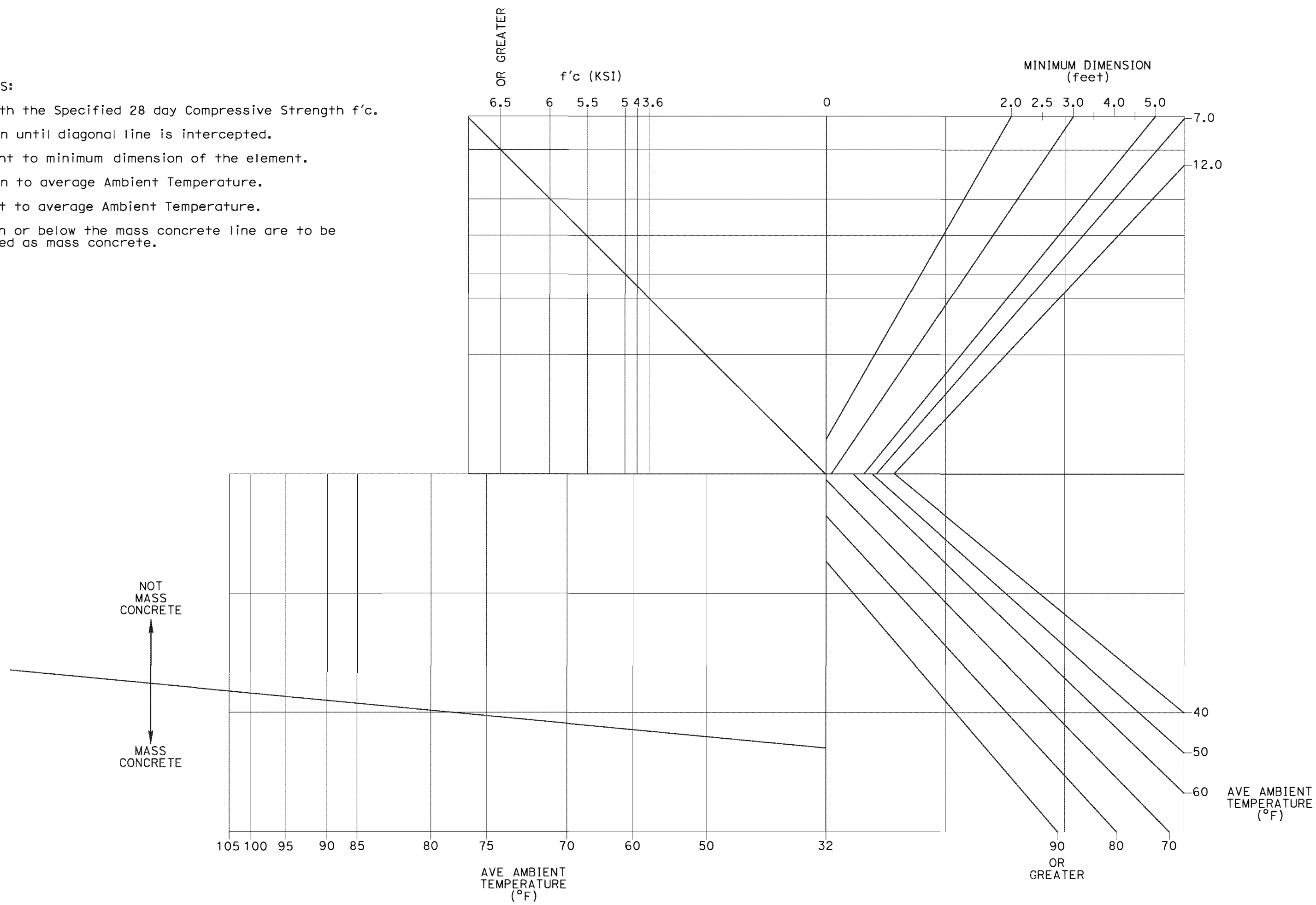

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Inyo	95
Kern	95
Kings	80
Lake	70
Lassen	55
Los Angeles	75
Madera	70
Marin	65
Mariposa	75
Mendocino	70
Merced	75
Modoc	60
Mono	60
Monterey	65
Napa	70
Nevada	70
Orange	75
Placer	75
Plumas	60
Riverside	75
Sacramento	75
San Benito	70
San Bernardino	80
San Diego	75
San Francisco	65
San Joaquin	75
San Luis Obispo	70
San Mateo	65
Santa Barbara	70
Santa Clara	70
Santa Cruz	65
Shasta	55
Sierra	55
Siskiyou	65
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