Surface chloride content in Thailand (User Manual)

1 General

Surface chloride content (Cs) refers to the quantity of chloride ions that gather on the surface of concrete structures, subsequently penetrating into the concrete and accumulating on the steel reinforcement, leading to corrosion of the steel. Surface chloride content is an important parameter for the design service life of concrete structures according to the standard of the Department of Public Works and Town & Country Planning (DPT 1332-55).

2 User manual

Research was conducted to propose a method for estimating the surface chloride content in coastal regions of Thailand. According to surface chloride content gathered from specimens and actual structures in the Gulf of Thailand and the Andaman Sea, a surface chloride prediction model was formulated. The surface chloride content can be determined by inputting values of influencing parameters on the website (https://thaicorrosionmap.mtec.or.th) as shown in Figure 1. In the prediction model (Equation (1)), surface chloride content can be estimated from the values of airborne chloride deposition (1), water to binder ratio (2), fly ash to binder ratio (3), exposure period or design service life (4), elevation above mean sea level (5), and terrain factor (6) as illustrated in Figure 1.

$$C_s = \beta \times 0.03 \times (C_a \times \gamma)^{0.38} \times (10 \times (1 - \exp(-0.1 \times t)) \times (1.7 \times E^{-0.3}) \times (0.55 \times (f/b - 0.7)^2 + 0.9) \times (1.2 \times \log(w/b) + 1.4) \quad (1)$$

where C_s is the surface chloride content (% by weight of binder), β is the wind direction factor (β = 1.0 in this study, the effects of wind direction should be included in the future study), γ is the terrain factor, Ca is the airborne chloride deposition (mmd), t is the exposure period or design service life (year), E is the elevation above mean sea level (m), f/b is the fly ash to binder ratio, and w/b is the water to binder ratio.

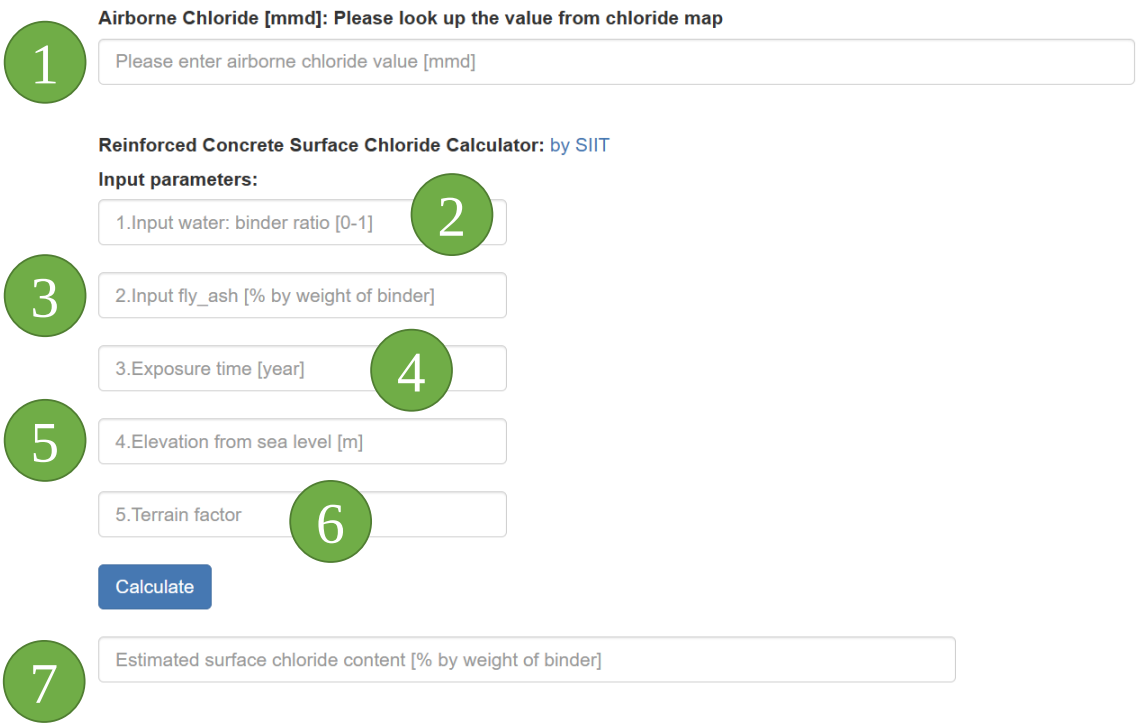

Figure 1 User manual for determine surface chloride content on website (https://thaicorrosionmap.mtec.or.th)

2.1 Airborne chloride deposition

The conflicts of sea wave create whitecaps that transported inland by wind characteristic known as airborne chloride. It is found that there is a correlation between surface chloride content and airborne chloride. Thus, airborne chloride is considered as one of the parameters to estimate the chloride content at the surface of concrete structures. Airborne chloride deposition can be determined using the chloride map on the website as shown in Figure 2. The user manual of airborne chloride map can be found in the website (usermanual_foruser.pdf (mtec.or.th)). From the value of airborne chloride on the map, user can use the value to determine the surface chloride content on the website **(**https://thaicorrosionmap.mtec.or.th**).**

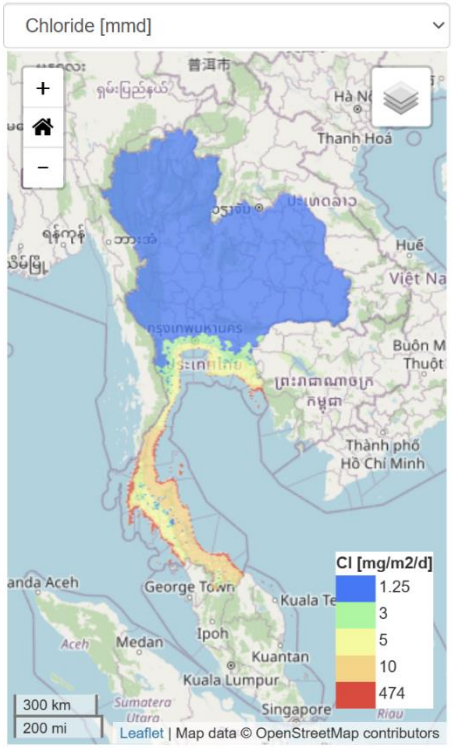

Figure 2 Airborne chloride map (Pongsaksawad et al., 2021)

2.2 Water to binder ratio

Water to binder ratio in concrete is the proportion of water to the total amount of cementitious materials (binder) used in concrete mixture. It is a critical factor influencing the workability, strength, and durability of concrete. Water to binder ratio is one of the parameters considered the surface chloride content of concrete structures as well. The water-to-binder ratio can be input on the website as a parameter based on the concrete mix proportions, enabling the determination of the surface chloride content. In the prediction model, water-to-binder ratio ranging from 0.3 to 0.65 were considered.

2.3 Fly ash to binder ratio

Users are required to input the fly ash to binder ratio value on the website according to the mix proportion of concrete, as this input serves as a parameter in calculating the surface chloride content using Equation (1). Fly ash to binder ratio is an important parameter influence the amount of chloride ions accumulated on the surface of concrete structures due to its filling effects and pozzolanic reaction affecting pore structures in concrete. Fly ash to binder ratio from 0 to 0.5 as cement replacement material were used in the analysis of the prediction model.

2.4 Design service life (Exposure period)

Exposure period is period of the concrete structure exposed in the marine environment. Users can input the exposure period of the concrete structures according to the required repair-free service life of the concrete structures. In this research, surface chloride contents were investigated in the actual structure exposed in the marine environment from 10 to 40 years.

2.5 Elevation above mean sea level

Elevation above mean sea level can be calculated from the google earth. Figure 3 depicts the elevation above mean sea level from Google Earth. From Figure 3, the elevation was determined at a location with latitude of 12º40′33″ and longitude of 100º54′57″. The elevation is shown at the bottom right of the screen on the Google Earth website (elevation of the interested point in Figure 3 is 43 m above mean sea level). This elevation is considered from the mean sea level to the earth surface. Users can add height of the interested parts of the concrete structures to the elevation value obtained from Google Earth. However, elevation of the data collected in the research was determined according to the height of the specimens, positions and collected points on the surface of the concrete structures as most of the elevations of the specimens were about 3m to 18m above mean sea level.

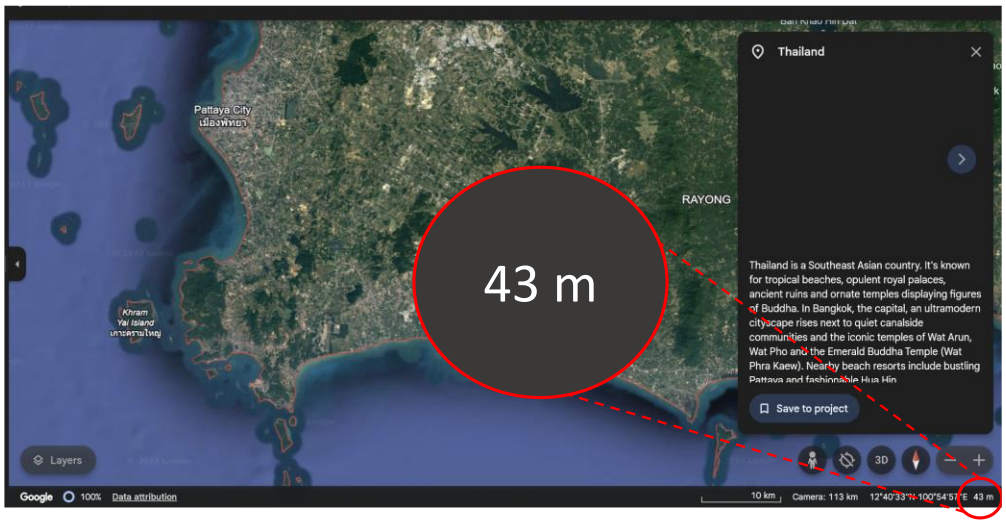

Figure 3 Elevation above mean sea level from Google Earth

2.6 Terrain factors

The surface chloride contents of structures also depend on geographical terrain. From the experimental data, concrete structures in different geographical conditions contain different levels of chloride ions accumulated at the surface of the concrete structures. It is noted that the terrain factors are established based on the surface chloride contents of the selected structures investigated in this research (see in Table 1).

Table 1 Terrain factors

Type of obstacles	Pictures of obstacles	Terrain Factor (γ)
No obstacle		1
Low fences		0.9
Trees		0.8

3-floor buildings		0.3
Mountains		0.1

2.7 Surface chloride content

Upon entering all the parameters outlined above, as illustrated in Figure 4, the calculation for surface chloride content can be performed. The prediction equation of surface chloride content was embedded in the website. Following the instructions provided above, users can input the parameter values and proceed to click 'Calculate,' as depicted in Figure 4, to obtain the surface chloride content of concrete structures in coastal regions of Thailand.

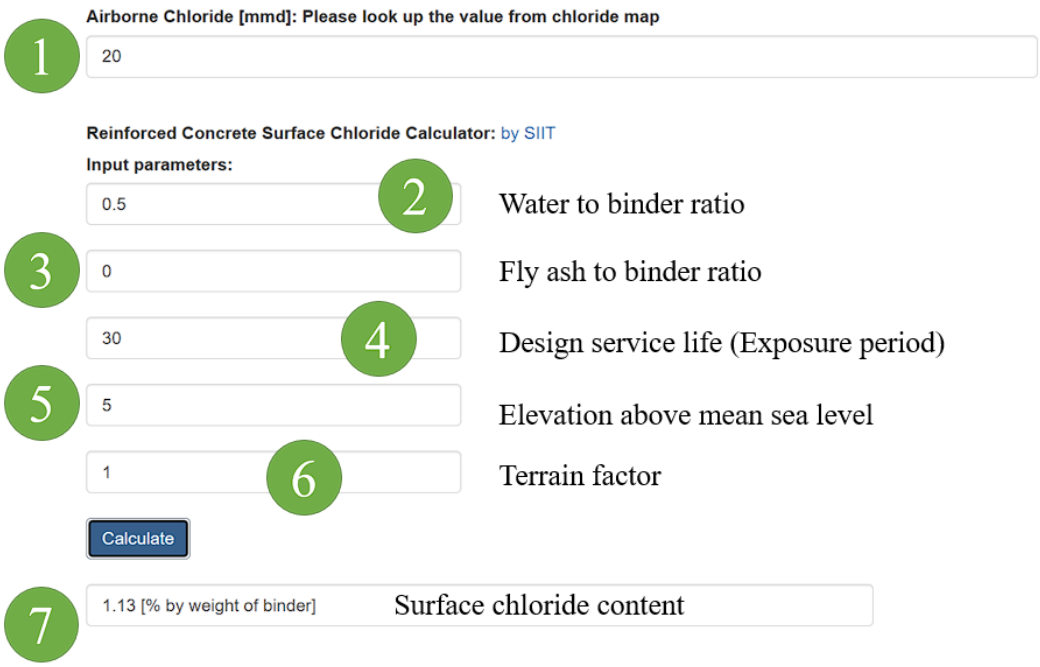

Figure 4 Determination of surface chloride content

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