# 社会資本アセットマネジメント(コンクリート橋)

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## １．研究概要

本稿では，社会資本/社会基盤施設（インフラストラクチャー）のアセットマネジメントシステムのうち，コンクリート構造物，特にコンクリート橋を対象とした部分について述べる。

アセットマネジメントシステムの構築に当たっては，「構造物の調査体制」と「構造物のライフスパンシミュレーション」の二大目標を設定し，それぞれについてシステムの確立を行う予定である。

ここで取り上げる対象は，コンクリート構造物のうち最も数が多く重要度が高いものであるコンクリート橋とした。コンクリート橋の機能を低下させる代表的な要因として塩害による鉄筋腐食を取り上げ，体制の整備および研究を行ってきた。

## ２．コンクリート構造物の塩害調査体制の整備

現在ある構造物のライフスパンシミュレーションには，その構造物の劣化状況を把握することが必要である。ここでは，特に塩害による鉄筋の腐食に着目し，そのライフスパンシミュレーションのためのデータ取得を目的として以下の機器を導入した。

**①KAMEN CHECKER(下面チェッカー：川田工業製)**

橋梁の桁下部を，足場を組むこと無しに路面から観察することが可能な機器。

**②携帯型鉄筋探査機(HILTI 製：PS200M)**

コンクリート構造物中の鉄筋の存在および表面からの深さ(かぶり厚さ)を，電磁波を用いて測定する非破壊検査機器。

**③携帯型鉄筋腐食診断機(四国総合研究所製：SRI-CM-Ⅲ)**

鉄筋の腐食度合いを診断する非破壊検査機器。

**④コンクリート表面研磨機および集塵機**

コンクリート表面の塩分濃度を測定するための機器。

以上の機器を用いることにより，塩害によるコンクリート構造物のライフスパンシミュレーションに必要な既存構造物に関するデータの収集を行う。

## ３．塩害に関する構造物のライフスパンシミュレーション

本プロジェクトでは，自然環境条件により塩化物イオンがコンクリート構造物表面に付着するプロセスについて研究を進めることにした。

コンクリート構造物表面に付着した塩化物イオンの進入についてはこれまでに多くの研究がなされている。一方，自然環境気象の影響によりどの程度の塩分が飛来しコンクリート構造物表面に付着するかについてはあまり研究がなされていない状況である。

なるべく多くのコンクリート構造物について飛来塩分量を推定することによりライフスパンシミュレーションの対象数を増やすことにつながる。そのためには，気象データから飛来塩分量を推定するモデルが必要であり，本プロジェクトに取り組むことにした。具体的には，波の飛沫により生じる塩分の飛来の構造物への付着，そして降雨による流出のシミュレーションである。

以下，その研究のあらましを説明する。

# Life span Simulation for Structures nearby Seashore Affected by Chloride Attack

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**Purpose:** To create a computational model to predict service-life of concrete structures located nearby seashore all over Japan to fulfill the life-cycle cost prediction in the asset management system.

**Main Tasks**:
To create an integrating model on the aerosol chlorides formation at the seashore, transport and theirs penetration in concrete to predict the structural life

**Model and Methodology:**
The model to predict the life-span of structures is the partial objective to achieve the social management. The social management is consisted of the inter-relation between the engineering knowledge and social safety and satisfaction. The development of infrastructure is one of the indicators of the social welfare. Many engineers play the intension to the design, advance construction method, and luxurious structures to promote the social. Another main item for social welfare is how to maintain the durable infrastructures and to prevent the social risk from the infrastructure damage. This concern was realized and implied a method to predict the life of an infrastructure. The common civil works which socials can use them are roads and bridges. The bridge structures are damage by chloride attack, if the location is nearby seashore. To be involved with social management, the prediction of life-span for a bridge structure is vital to be promoted. Here, the research items and progress is mentioned in this document. The benefit of this research is able to apply in the asset management for the infrastructure in term of life-cycle cost prediction method.

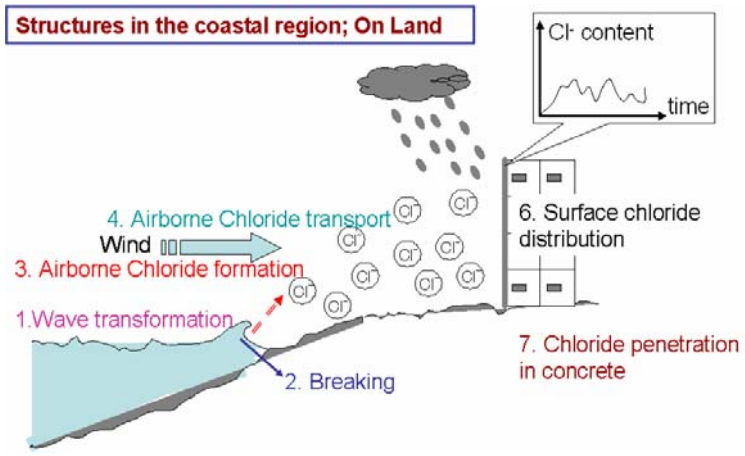


**Fig.1**: Schematic of chloride attack on concrete structures near seashore

In Fig.1, the model was started to calculate the amount of aerosol chlorides produced by wave breaking at the seashore. This is included the wave propagation from deep water zone to the surf zone. The database of wind and wave (Japan Meteorological Agency) for analysis time-dependent aerosol chlorides formation is necessary. The model was created in the function with the important environmental parameters of wind speed[3], wave height[2], salt concentration and breakwater [*See Publication 1 & 2*]. One more parameter will be added in the model is the temperature effect which causes the different amount of aerosol chlorides formation due to the surface tension and viscosity difference. The methodology is to create a multiplication factor for this temperature effect adding in the above purposed model.

Considering the bridge structures in Japan, the bridges for road transportation across the river are in services, and some of them were found many damages by steel bars corrosion. Thus, the aerosol chlorides formation along the estuary is much concentrated. The salt concentration at the river estuary is variety due to the tidal effect and also the river steam discharge. The methodology to calculate apparent salt concentration is to create a function of freshwater and sea water mixing mechanism including the tidal cycles and amount of rainfall. At the beginning, the case study on the rivers in Kochi prefecture shall be studied. In this case, the river discharge database (Kochi Prefecture River Department Bureau) and tidal cycles (Japan Oceanography Data Center) should be analyzed with the amount of rainfall (obtained from the Japan Meteorological Agency). In this part, the atmospheric pressure shall be taken into account as mentioned: 'The low pressure inside the storm raises sea level by 1cm for each millibar decrease in pressure'. During typhoon, large numbers of aerosol chlorides are formed significantly larger than in mild environment. Thus, the low atmospheric pressure during storm and the lifting of sea level impacts on the surging of wave at seashore.

The breakwater is the artificial construction to prevent the storm wave to reduce the damage due to wave force. The breakwater constructed along the Japan coastal is divided in common caisson, irregular concrete block, and under water caisson, etc. The aerosol chlorides are generated in the different amount among three different types of breakwaters.

**→ 2nd model on aerosol chlorides Transportation**

The transportation of aerosol chlorides is moving within the wind steam flow. The sedimentation of spherical particles was modeled simply. In the turbulence wind flow, the aerosol particles moving according to the wind profile both in horizontal and vertical motion. Moreover, the aerosol particles are moving upward by the turbulence of wind which is represented by the vertical eddy diffusivity. The eddy diffusion coefficient shall be modeled under the strong turbulence wind. At this moment, the analysis of wind profile from seashore and surrounding bridge structure is doing. The analysis of wind vortex between bridge girders is still doubtful, because this wind analysis could not be verified by the experimental data of surface chloride content. The measurement of aerosol chlorides and surface chlorides content at slab and girder of Ananai and Akano bridges in Kochi Prefecture is continuing. The monitoring of existing

RC bridge named Ananai Bridge in Kochi prefecture; the surface chloride concentration and the amount of aerosol chloride in an interval were investigated as shown in **Fig.2**. Furthermore, the surface chloride contents, covering depth and the steel corrosion contour are further established to analyze the structural performance and the damage parts.

In the future task, the integration of all models for the prediction of structural life-span shall be established and promote to be used in the other societies.

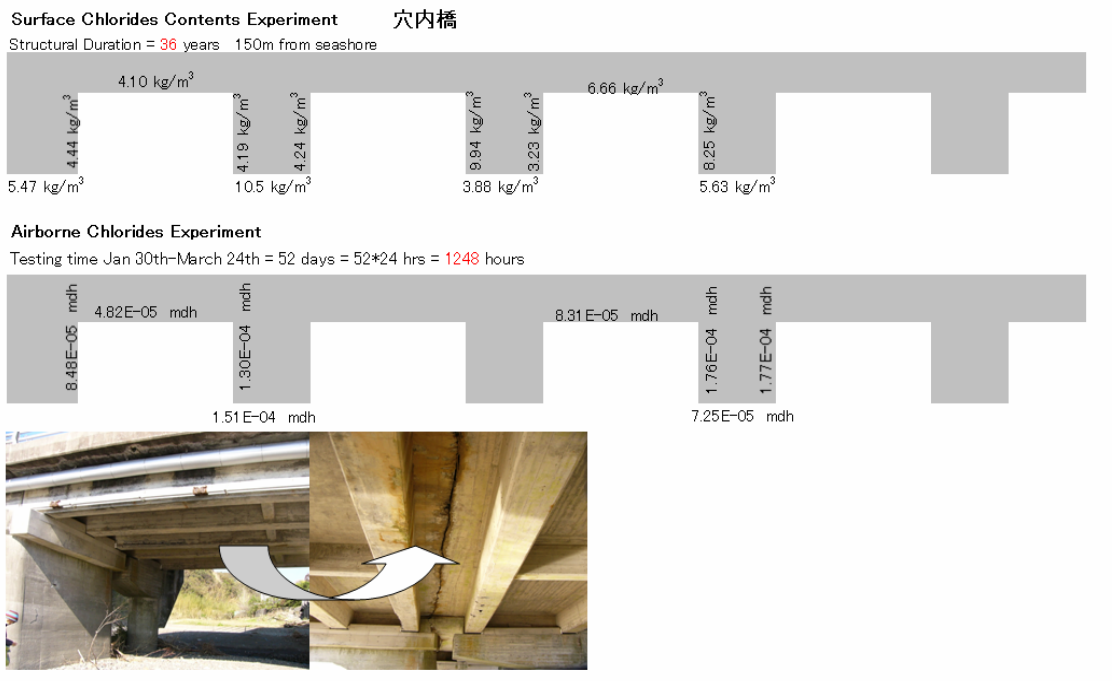


**Fig.2**: The monitoring of aerosol chlorides (mg/dm$^2$/hr) and surface chloride content (kg/m$^3$) at Ananai Bridge

## Publications:


1. Swatekititham S., 'An Estimation Method for the Airborne Chlorides Formation at the Japan Coastline', Third International Conference; Construction Materials, Performance, Innovations, and Structural Implications; ConMat'05, Vancouver, Canada, Aug, 2005
2. Swatekititham S., 'Offshore Oceanography on the Aerosol Chlorides Formation during Typhoon Period', 60$^{th}$ Annual Conference of Japan Society of Civil Engineers, Tokyo, Sep, 2005


## Future Publications: (In Abstract Process)


1. Swatekititham, S. 'Aerosol Chlorides Formation and Transport to RC Structures', the 22nd Biennial Concrete Conference, Melbourne, Australia, Oct, 2005
2. Swatekititham, S. 'Non-destructive Life-span Simulation for RC Structures under Japan Oceanography' 2$^{nd}$ international *fib* Congress, Naples, Italy 5-8 June, 2006