別紙４（課程博士）

Date of Submission:
平成 29 年 1 月 11 日

Department 機械工学専攻	Student ID Number 学籍番号	第 149104 号
Applicant's name 氏名	星野雅彦	

Supervisors 指導教員	福本 昌宏 松本 明彦 三浦 均也 松本 幸大

Abstract

論文内容の要旨 (博士)

Title of Thesis 博士学位論文名	港湾環境下におけるペトロラタム被覆防食材および被覆防食工法の劣化機構の解明 (Elucidation of Deterioration Mechanism of Petrolatum Materials and Lining System in Marine Environment)

(Approx. 800 words)
(要旨 1,200 字程度)

港湾鋼構造物の防食法の１つであり，多くの実績があるペトロラタム被覆防食工法の劣化機構について検討を行った。主材料であるペトロラタム系防食材（以下、防食材）と FRP 保護カバー材（以下、FRP）に着目し、それぞれの劣化機構について検討した。また、ペトロラタム被覆防食工法は、鋼材の防食が目的であるため、防食材や FRP の劣化が鋼材の腐食に与える影響についても検討した。さらに、現在の維持管理手法の主手法である目視調査の問題点について整理し、安易かつ時間短縮が可能な維持管理手法について提案した。以下に本研究で得られた知見を示す。

（1）防食材は酸化による低分子量化が主体の劣化を生じ、その劣化は暴露年数が増加するにつれて進行する．劣化は温度による影響が大きいと考えられ，実環境下では直射日光の影響を受けやすい飛沫帯にその傾向が表れやすいことが分かった．また，劣化した防食材は，親水的なカルボニル基を生じることから，鋼材表面へ水分を供給しやすい原因になることも明らかとなった．

（2）欠陥率測定や電気化学的測定を実施することで実環境下における防食材の劣化と鋼材腐食の関係性を解明した．特に飛沫帯では，温度の影響を受けた防食材が下方へ流動し，不織布の縫い目を起点として防食材に物理的な欠陥を生じ，波浪による水分や気中の酸素といった腐食因子が防食材に生じた欠陥部を起点に鋼材表面へ到達することで腐食することが明らかとなった。

（3）FRPの劣化は，樹脂の酸化と加水分解が主であることが明らかとなった．酸化と加水分解では，加水分解の方が劣化に与える影響は大きく，温度変化よりも水が関与する劣化が機械的強度に与える影響は大きいことが分かった．また、一般的なFRPとは異なり紫外線が強度低下に与える影響は小さかった．

（4）FRPの機械的強度の低下は，表面から内部に向かって徐々に劣化が進行していくことに起因し，その強度の低下は，引張強度よりも曲げ強度に顕著に表れることが明らかとなった．目視の色調変化程度と機械的強度には明確な関係性はないことが分かった．

（5）鋼材の腐食を意味する工法の劣化は，特に飛沫帯に影響が出やすいことが分かったため、劣化判断は飛沫帯の防食材および鋼材表面について実施することが望ましい．なお、飛沫帯が健全である場合，干満帯や海水中も健全である可能性が高い．また、FRP は，暴露年数が増加するにつれ表面が劣化し，機械的強度が低下していく傾向があるが，破損や脱落等の異常がない状態であれば，鋼材腐食には直接大きな影響は与える影響は小さい．

（6）現在の目視調査主体の維持管理手法は鋼材の防食状態を評価する手法としては問題があることか

ら、簡易かつ早期の判断が可能な欠陥率による新たな評価手法を提案した。欠陥率測定に用いる防食材の回収位置は飛沫帯とし，測定される欠陥率の閾値を 0.2%とすることを提案した.

別紙４（課程博士）

Date of Submission:
平成 29 年 1 月 11 日

Department	Student ID Number	
Mechanical Engineering	学籍番号	第 149104 号
Applicant's name 氏名	Masahiko Hoshino	

Supervisors 指導教員	Masahiro Fukumoto Akihiko Matsumoto Kinya Miura Yukihiro Matsumoto

Abstract

論文内容の要旨 (博士)

Title of Thesis 博士学位論文名	Elucidation of Deterioration Mechanism of Petrolatum Materials and Lining System in Marine Environment

(Approx. 800 words)
(要旨 1,200 字程度)

The deterioration mechanism of the petrolatum lining system which is a popular corrosion prevention method for marine steel structures was investigated. The deterioration mechanism of the petrolatum material (henceforth referred to as "anticorrosion material") and fiber-reinforced plastic (FRP) protective cover material (henceforth referred to as "FRP") was investigated. Additionally, since the objective of the petrolatum lining system is the prevention of the corrosion of steel materials, the effect of the deterioration of the anticorrosion material and FRP on the corrosion of steel materials was also investigated. Furthermore, the drawbacks of visual examination, which is the primary maintenance method currently used, were analyzed and a new facile and less time-consuming maintenance method was proposed.

The findings from this study are summarized below.

(1) The anticorrosion material deteriorated mainly by oxidative degradation. The deterioration proceeded as the exposure time under practical environment increased. It was found that the temperature affected the deterioration significantly. The deterioration occurred readily in the splash zone, which is susceptible to the effect of direct sunlight in a practical environment. It was also revealed that the deterioration of the anticorrosion material supplied moisture to the surface of steel materials, because the deterioration material produced hydrophilic carbonyl groups.

(2) The relationship between the degradation of the anticorrosion material and the corrosion of steel materials in practical environment was elucidated implementing the defect rate measurement and electrochemical measurement. Especially in splash zone, the anticorrosion material was affected by temperature and flowed downward, resulting in physical defects in the anticorrosion material originating from the stitches of nonwoven fabrics. It was found that the corrosion occurs when the corrosion factors, such as moisture originating from ocean waves and oxygen in the air, reach the surface of steel materials originating from the defective portion in the anticorrosion material.

(3) It was revealed that the deterioration of FRP of was mainly due to the oxidation and hydrolysis of the polyester resin. The deterioration was influenced more by hydrolysis than by oxidation, and the water-assisted deterioration of FRP influenced its mechanical strength more than the temperature-assisted deterioration. Additionally, the effect of ultraviolet light on the strength of the FRP material used in this study was smaller than on the typical FRP.

(4) It was revealed that the reduction in the mechanical strength of FRP is due to the gradual progress of the deterioration from the surface toward the inside, and the reduction in the strength was more remarkable for bending than for tensile. It was also found that there was no clear relationship between the degree of color tone change (as observed by visual examination) and the mechanical strength.

(5) It was found that the deterioration of the lining, which leads to the corrosion of the steel materials, tends to influence the splash zone. Therefore, it is desirable to carry out the investigation of the deterioration mechanism of the anticorrosion material and the surface of steel materials in the splash zone. If the structure in the splash zone is robust, the structure in the tidal zone and in the seawater is also likely to be robust. Although the surface of FRP has a tendency to deteriorate and its mechanical strength decreases according to the length of exposure, the chances of its deterioration affecting the corrosion of steel materials are negligible in the absence of any abnormality such as damage or separation.

(6) New evaluation method based on the defect rate allowing easy and earlier evaluation was proposed. It was also proposed that the collection position of the anticorrosion material to be used for the defect rate measurements be located at the splash zone and the threshold value of the defect rate to be measured shall be 0.2%.