Research Report（September, 2021 - March, 2024）

In the SGU course of Mathematical Physical Science: September 2021-March 2024

Conferring university	Degree name (by completing a course / by thesis only)	Date of conferment
Waseda University	Doctor of Engineering	03 15, 2024

Enrollment from September 2021	Department of modern mechanical engineering	Yasutoshi Taniguchi

Ⅰ. List of Papers

1. Y. Taniguchi, K. Takizawa, Y. Otoguro, and T.E. Tezduyar, “A hyperelastic extended Kirchhoff–Love shell model with out-of-plane normal stress: I. Out-of-plane deformation”, *Computational Mechanics*, **70** (2022) 247–280, doi: 10.1007/s00466-022-02166-x.
2. Y. Taniguchi, K. Takizawa, Y. Otoguro, and T.E. Tezduyar, “A hyperelastic extended Kirchhoff–Love shell model with out-of-plane normal stress: II. An isogeometric discretization method for incompressible materials”, *Computational Mechanics*, to appear, 2024.
3. H. Takeda, Y. Asai, S. Ishida, Y. Taniguchi, T. Terahara, K. Takizawa, and Y. Imai, “Isogeometric boundary element analysis of creasing of capsule in simple shear flow”, *Journal of Fluids and Structures*, **124** (2024) 104022,
doi: https://doi.org/10.1016/j.jfluidstructs.2023.104022.
4. Y. Asai, S. Ishida, H. Takeda, G. Nakaie, T. Terahara, Y. Taniguchi, K. Takizawa, and Y. Imai, “A computational model of red blood cells using an isogeometric formulation with T-splines and a lattice Boltzmann method”, *Journal of Fluids and Structures*, **125** (2024) 104081,
doi: https://doi.org/10.1016/j.jfluidstructs.2024.104081.

Ⅱ. Record of Awards

JSCES Scholarship Award (2023)

Ⅲ. List of Talks

International Lectures

1. Y. Taniguchi, K. Takizawa, and T.E. Tezduyar, “A hyperelastic Kirchhoff–Love shell model with out-of-plane normal stress”, in *The 15th World Congress on Computational Mechanics (WCCM XV) and the 8th Asia–Pacific Congress on Computational Mechanics (APCOM VIII)*, Online due to the COVID-19, (2022).
2. Y. Taniguchi, K. Takizawa, Y. Otogro, and T. Tezduyar, “A hyperelastic extended kirchhoff–love shell model with out-of-plane normal stress: Comparison with the plane-stress model”, in *Extended Abstracts of Advances in Computational Mechanics (ACM2023)*, Texas, USA, (2023).

Domestic Lectures

1. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “Isogeometric 離散化に基づく面垂直応力の厚み方向変化を考慮した Kirchhoff–Love シェル定式化の検討”, in 日本計算工学会 第 26 回計算工学講演会, Online due to the COVID-19, (2021).
2. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “Isogeometric 離散化に基づく面垂直応力を考慮した Kirchhoff–Love シェル定式化 ―平面応力シェルとの比較・検討―”, in 日本応用数理学会 2021 年度年会, Online due to the COVID-19, (2021).
3. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “Isogeometric 離散化に基づく面垂直応力の厚み方向変化を考慮した Kirchhoff–Love シェル: 境界条件式に関する考察”, in 日本機械学会第 34 回計算力学講演会, Online due to the COVID-19, (2021).
4. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “赤血球膜に対する Skalak 構成則による弾性体近似の妥当性検証”, in 日本機械学会 第 32 回バイオフロンティア講演会, Online due to the COVID-19, (2021).
5. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “厚み方向垂直応力を考慮した拡張 Kirchhoff–Love シェル の定式化”, in 科学技術振興機構 若手数学者交流会 (第 3 回), Online due to the COVID-19, (2022).
6. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “Skalak 構成則に基づく曲げ剛性を考慮した新しい赤血球膜モデル―静止形状解析による妥当性検証―”, in 日本機械学会 第 33 回バイオフロンティア講演会, 神戸, (2022).
7. 谷口靖憲, 滝沢研二, and テズドゥヤー・タイフン, “赤血球膜に対する膜圧を考慮したシェル理論に基づく定式化”, in 日本応用数理学会 第 19 回研究部会連合発表会, 岡山, (2023).
8. 谷口靖憲, 滝沢研二, 乙黒雄斗, and テズドゥヤー・タイフン, “厚み方向垂直応力を考慮した拡張 Kirchhoff–Love シェルによる非圧縮薄肉構造のアイソジオメトリック解析”, in 日本計算工学会 第 28 回計算工学講演会, 筑波, (2023).
9. 谷口靖憲, 滝沢研二, 乙黒雄斗, and テズドゥヤー・タイフン, “厚み方向垂直応力を考慮した拡張 Kirchhoff–Love シェルによる非圧縮薄肉構造の定式化―厚み方向垂直応力が曲げ剛性にもたらす効果についての考察―”, in 日本応用数理学会 第 20 回研究部会連合発表会, 長岡, (2024).

Ⅳ. Research Results in AY 2023

In this year, we developed a method for the computational implementation of a hyperelastic extended Kirchhoff–Love shell, which we formulated in FY2021. For incompressible materials, the variable expressing thickness variation is eliminated by the incompressibility constraint, which means the behavior of the thickness variation is completely written by two-dimensional surface called “midsurface”. This allows us to introduce the mechanics of thickness for the same number of variables as preceding plane-stress models. For compressible materials, the mechanics of thickness can be solved by introducing “volume ratio” as a temporary variable to describe thickness only with local information. This allows us to introduce the mechanics of thickness for the same number of variables as preceding plane-stress models.

Ⅴ. Summary (From September 2021 to May 2024)

During my enrollment in this course, I mainly worked under Professor Takizawa on the “introduction of the mechanics of thickness to Kirchhoff–Love shell model and development of its computation method”. In this research, we have proposed not only the formulation, which is newly accounted into the mechanics of thickness, but also to propose and realize the computation of it within the framework of conventional plane-stress shells. I am very grateful to SGU Top Global University Project for the great opportunity.