Manuscript No: AeroJ-2022-0058

Paper Review Responses

Dear editors and reviewers:

Thank you very much for your review and helpful comments on the manuscript AeroJ-2022-0058 entitled "Conceptual design and application research of a corrugated flexible skin with high bending stiffness" submitted for publication in The Aeronautical Journal. These professional comments are indispensable for improving the quality of the paper. According to your observations, the manuscript has been revised. For an easier review process, the changes have been highlighted by yellow and the original texts have been highlighted by green. Below are our detailed paper review responses.

Sincerely yours,

Pengbo Lei, Yi Li, Dingding Li, Bin Li

Content

Reply to Reviewer1

Thank you very much for your time in reviewing the paper and valuable feedback. And, in the following sections we answered these questions.

Comment 1:

The language can be enhanced: there is room for improvement, especially on grammar/typos. It is recommended that manuscript be read by a native English speaker to improve readability and comprehension.

Response 1:

We have checked and corrected the grammatical errors and typos we found in our revised manuscripts.

In abstract, the sentences:" In this paper sliding panels are used to increase the bending stiffness of the classic corrugated flexible skin, and the corresponding application procedure for aircraft structures is developed." were changed to " In this paper, sliding panels are used to increase the bending stiffness of the classic corrugated flexible skin, and the corresponding application procedure for aircraft structures is developed. "

The sentences:" After the conceptual design of the corrugated flexible skin with sliding panels is proposed, the analytical model to calculate the equivalent tensile and bending properties is investigated." were changed to " After the conceptual design of the corrugated flexible skin with sliding panels is proposed, the analytical models to calculate the equivalent tensile and bending properties are investigated. "

The sentences:" The results show that the corrugated flexible skin with sliding panels have more bending stiffness than the classic corrugated flexible skin in the direction perpendicular to corrugation while maintaining the deform ability in the corrugation direction, and the application procedure is effective and can be applied to other parts of aircraft structure." were changed to " The results show that the corrugated flexible skin with sliding panels has more bending stiffness than the classic corrugated flexible skin in the direction perpendicular to corrugation while maintaining the deform ability in the corrugation direction, and the application procedure is effective and can be applied to other parts of the aircraft structure. "

In page 2, the sentences:" To satisfy these conflicting requirements, many deigns of flexible skin are proposed, and Thill gave a comprehensive review of flexible skins and corresponding material system[10]." were changed to " Therefore, the requirements for flexible skin are conflicting, for this problem, many deigns of flexible skin were proposed. Thill gave a comprehensive review of flexible skins and corresponding material system[10]. "

In page 4, the sentences "This improvement is verified by tensile and bending numerical simulation, the analytical solution to calculate the equivalent tensile and bending properties and comparison between these two kinds of flexible skins are also investigated." were changed to "This improvement is verified by tensile and bending numerical simulation, and analytical models for calculating the equivalent tensile and bending properties of two kinds of flexible skins are also investigated. "

In page 5, the sentences " When this corrugated flexible skin is used for aircraft with consideration of flexibility in the corrugation direction, materials with low modulus are usually selected and the thickness of the panels and corrugated core is reduced." were changed to " When this corrugated flexible skin is used for morphing aircraft, flexibility along corrugation direction is required to produce continuous smooth deformation, materials with low modulus are usually selected and the thickness of the panels and corrugated core is reduced. "

In page 6, the sentences "This results in a significant reduction in the tensile stiffness of the ICFS." were changed to " This results in a certain reduction in the tensile stiffness of the ICFS. "

In page 6, the sentences "In this case, the sliding panels grind against each other, as they are made of high modulus material, the bending deformation of the ICFS can be limited effectively. Thus, the ICFS is a capable of offering a higher bending stiffness than the CCFS, and has larger aerodynamic load capacity." were changed to "In this case, the sliding panels made of high modulus material squeeze each other, the bending deformation of the ICFS can be limited effectively. Thus, the ICFS is a capable of offering a higher bending stiffness than the CCFS, and has larger aerodynamic load bearing capacity.

In page 8, the sentences "(2) For the improved flexible corrugated skin, smooth contact between sliding panels does not provide any tensile stiffness under tensile or bending condition." were changed to "(2) For the improved flexible corrugated skin, it is assumed that the sliding panels are in smooth contact with each other and do not provide do not provide any tensile stiffness under tensile or bending conditions."

In page 8, the sentences "Some necessary assumptions should be proposed for simplifying the calculation process as follows" were changed to " Two necessary assumptions should be proposed for further simplifying the calculation process as follows"

In page 8, the sentences " Geometric parameters of classic corrugated flexible skin under tensile condition are shown in Fig. 3(a), the objective is to calculate the tensile displacement that can be applied for evaluating the equivalent elastic modulus of this structure." were changed to " Geometric parameters of classic corrugated flexible skin under tensile condition are shown in Fig. 3(a), our objective is to calculate the tensile displacement which can be applied for evaluating the equivalent elastic modulus of this structure."

In page 9, the sentences " In order to avoid dealing with the indeterminate loading configuration, the structure is divided into two parts including corrugated core and lower panel (Fig. 3(b)), and the compatibility equation that tensile displacement of part $CABD$ of the corrugated core is equal to that of the lower panel is obtained." were changed to " To avoid dealing with the indeterminate loading configuration, the structure is divided into two parts including corrugated core and lower panel (Fig. 3(b)), and the compatibility equation that tensile displacement of part $CABD$ of the corrugated core is equal to that of the lower panel is obtained. "

In page 9, we added the sentences " The specific calculation process is as follows."

In page 11, we also added the sentences " The specific calculation process is as follows."

In page 20, the sentences "According to the conceptual design in Section 2.1, the specimens of two flexible skins (the CCFS and ICFS, as shown in Fig. 14) are designed and manufactured by 3D printing technology to investigate the abilities of stretching in the corrugation direction and resisting load in the direction perpendicular to corrugation." were changed to "In this section, the specimens of two flexible skins (the CCFS and ICFS, as shown in Fig. 14) are designed and manufactured by 3D printing technology to examine the capacities of stretching in the corrugation direction and resisting load in the direction perpendicular to corrugation."

In page 21, the sentences "Due to limitation of capability of 3D printer, the corrugated cores of the specimens are consisted of five units." were changed to " Due to limit of capability of 3D printer, the corrugated cores of two specimens are consisted of five units."

In page 22, the sentences " For the bending case, the load is simulated by a weight located on the upper panel of the specimen, deformations of center in length of the specimen are measured by laser rangefinder." were changed to " For the bending case, the load is simulated by a weight located on the upper panel of the specimen, deformations of the specimen center point are measured by laser rangefinder."

In page 23, the sentences "It shows that the bending deformation of the ICFS is significantly decreased by 5 times comparing with the that of CCFS." were changed to " It shows that the bending deformation of the ICFS is significantly decreased by 5 times compared with the that of CCFS."

In page 25, the sentences "The load capacity is determined by local stiffness and global stiffness." were changed to "The load carrying capacity is determined by local stiffness and global stiffness. "

In page 25, the sentences " In tensile deformation of the ICFS, the allowable strain of the whole structure should be determined based on the part where there is maximum value of the strain in the ICFS. The allowable strain of the ICFS equals to the limit strain of material of this part." were changed to " In tensile deformation of the ICFS, the allowable strain of the whole structure should be determined based on the part where there is maximum value of the strain in the ICFS, and the allowable strain of the ICFS equals to the limit strain of material of this part. "

In page 28, the sentences " The lower right corner of the demonstrator is hinged and the entire leading edge can rotate around it." were changed to " The lower right corner(point B) of the demonstrator is hinged and the entire leading edge can rotate around it. "

In page 29, the sentences " The drooping leading edge without the ICFS is deflected downward by angles of $6°, 8°, 10°$ and the profiles of them is drawn by different color lines as shown in Fig. 24." were changed to " The drooping leading edge without the ICFS is deflected downward by angles of $6°, 8°, 10°$ and the profiles of them are drawn by different color lines as shown in Fig. 24. "

In page 31, the sentences "More aerodynamic load can be resisted by grinding against each other between the sliding panels, it means that the bending stiffness is significantly enhanced." were changed to " More aerodynamic load can be resisted by squeezing each other between the sliding panels, it means that the bending stiffness is significantly enhanced. "

Comment 2:

Please, capital letters before acronyms.

Response 2:

We use two acronyms in this paper, as shown in the table below: the CCFS represents the classic corrugated flexible skin, and the ICFS represents the improved corrugated flexible skin.

Table 1. *The acronyms used in this paper*

Acronyms	Meaning
CCFS	the classic corrugated flexible skin
ICFS	the improved corrugated flexible skin

Comment 3:

The Introduction section frames the study in terms of a global point of view, but the technical state of art that supports this subject is very poor. It is recommended that there should be a comparison of the presented study with the conventional literature studies, to provide more information on the novelty of the proposed approach. I would suggest you include some noted papers in the subject of morphing structures (e.g., "Morphing shell structures: a generalised modelling approach", "A morphing composite air inlet with multiple stable shapes", "Numerical and experimental study of bistable plates for morphing structures") and deformation behaviour concerning analytical morphing models, starting point for further modelling phase (e.g., "Analytical models for bistable cylindrical shells", "Shape prediction of bistable plates based on Timoshenko and Ashwell theories", "Analytical modeling for rapid design of bistable buckled beams" …).

Response 3:

According to the literatures recommended by the reviewer, we added the relevant contents to the introduction of the paper in page 2: " Some scholars have done a lot of work in the subject of morphing structures: Lamacchia has addressed the main challenges of describing the multistable behaviour of thin composite shells through the development of an accurate and computationally efficient energy-based method[4]. Daynes has achieved structural multistability using a novel combination of material prestress and bending stiffness tailoring[5]. Nicassio has explored potential configurations of the bistable plates and their dynamic behavior for designing novel morphing structure suitable for aerodynamic surfaces[6]. Deformation behavior concerning analytical morphing models of these morphing structure has also been studied: Guest has presented a simple two-parameter model for thin cylindrical shell structures to distinguish different stable behaviours[7]. Nicassio has developed an analytical model to provide an interpretation of the bistable shapes in terms of principal and anticlastic curvatures[8]. Yan has presented a method to easily and rapidly design bistable buckled beams subjected to a transverse point force[9]." At the same time, the corresponding references section were modified.

Comment 4:

Please, avoid group citation with more than 3 papers and check the cited authors (e.g., for ref [21], Francesco is not the author surname!).

Response 4:

We separately introduced the references which were group cited before.

In page 2, the sentences "Shape-memory polymers (SMPs) possess the advantages of high elastic deformation, thus they were chosen and investigated as morphing skins[5-8]." were changed to "Shape-memory polymers (SMPs) possess the advantages of high elastic deformation, thus they were chosen and investigated as morphing skins: Reed has addressed integration of their shape memory polymer materials into the wing skin to enable seamless morphing[11]. Sun has mixed elastic fibers into pure shape memory polymers to solve the problem that they are brittle in glassy state[12]. Keihl has investigated basic characterization of a shape memory polymer (SMP) as a suitable structural material for morphing aircraft applications[13]. McKnight has fabricated and tested several design of laminar morphing materials using a commercial shape memory polymer[14]."

In page 3, the sentences "After that, several corrugated structures with various geometries and materials were designed and studied[14-19], and recently the shape of the corrugated core was optimized by Ermakova to obtain lager deformation[20]." were changed to "After that, several corrugated structures with various geometries and materials were designed and studied[20, 21]. Dayyani provided an analytical homogenization model which uses the geometric and mechanical properties of panel as variables that can be applied for further optimization studies, and two analytical solutions to calculate the equivalent tensile and bending flexural properties of a coated composite corrugated core in the longitudinal and transverse directions are presented[22]. Kharati-koopaee investigated the effect of corrugated skins on the aerodynamic performance of the cambered NACA 0012 airfoils at different corrugations parameters, maximum cambers, Reynolds numbers and maximum camber locations[23]. Dayyani investigated the design employs the biologically inspired compliant structure known as the FishBAC and corrugated skin to create large continuous changes in airfoil camber and section aerodynamic properties[24]. Thill have studied the application of corrugated sandwich structures, and the panels made from multiple unit cells of corrugated sandwich structures are used as morphing skin panels in the trailing edge region of a scaled morphing airfoil section[25]. Recently, the shape of the corrugated core was optimized by Ermakova to obtain lager deformation[26]."

We checked the cited authors and changed some sentences.

In page 3, the sentences "Yijin Chen designed and fabricated a kind of morphing skin embedded with pneumatic muscle fibers from the bionics perspective[10, 11]." were changed to " Chen designed and fabricated a kind of morphing skin embedded with pneumatic muscle fibers from the bionics perspective[1, 2]. "

In page 4, the sentences "Aim at first problem, Alessandro Airoldi used honeycomb stripes to support the valleys of corrugation core, and then the local waviness of skin was limited[3]." were changed to "Aim at first problem, Airoldi used honeycomb stripes to support the valleys of corrugation core, and then the local waviness of skin was limited[3]."

In page 4, the sentences "In order to solve the second problem, Francesco added two vertical webs to each corrugated elements to enhance the bending stiffness of corrugated flexible skin[21]." were changed to "In order to solve the second problem, Previtali added two vertical webs to each corrugated elements to enhance the bending stiffness of corrugated flexible skin[27]."

Comment 5:

Only limited info concerning the FE Abaqus model: were meshing convergence studies carried out in order to obtain good time-solving and results accuracy?

Response 5:

We performed mesh convergence studies of the finite element model and added the following contents to the article in page 17.

"We have performed mesh convergence and computational efficiency of the finite element model by taking the improved corrugated flexible skin(ICFS) under tensile condition as an example through Abaqus software. Since the whole flexible skin is simulated by shell element, the minimum mesh size should be larger than thickness of the shell element in this study. The maximum tensile deformation(U) of the ICFS as mesh size reduced from 15mm to 2mm and computation time of its finite element model is shown in table 5 and Fig. 11. The result reveals that the tensile deformation values tend to be between 90mm and 95mm as the decrease of mesh size, and its computation time increases exponentially when the mesh size is less than 3mm. Therefore, in order to obtain good time-solving and results accuracy, we have chosen 3mm as mesh size during numerical simulations of two kinds of flexible skin. "

Table 5. *The maximum tensile deformation(U) of the ICFS and its computation time as mesh size reduced from 15mm to 2mm*

Mesh size(mm)	15	14	13	12	11	10	9
U(mm)	57.12	89.81	79.08	88.52	89.08	86.95	85.80
$Time(s)$	34	34	37	38	36	38	38
Mesh size(mm)	8	7	6	5	4	3	2
U(mm)	92.76	93.17	90.93	92.67	94.07	92.80	94.18
$Time(s)$	43	46	56	56	72	136	524

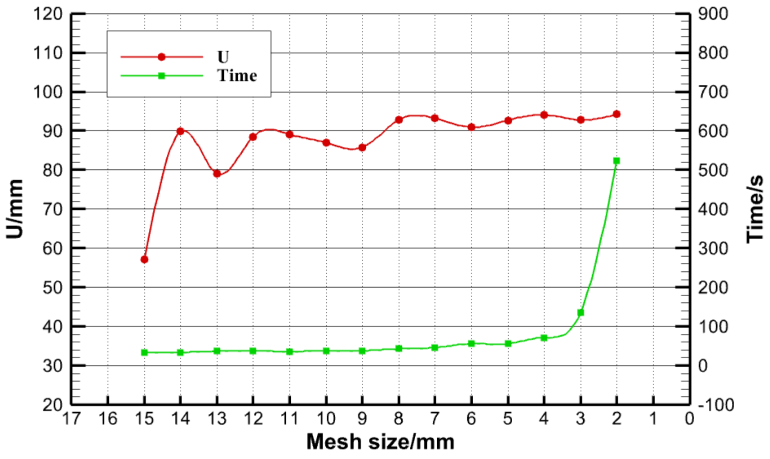
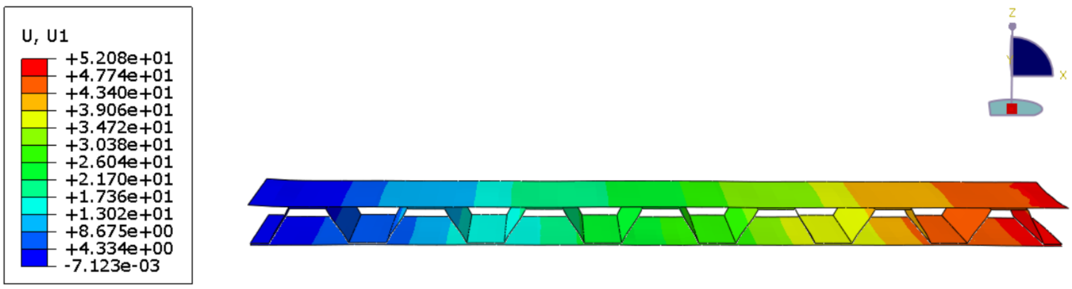


Figure 11. *Meshing convergence and computational efficiency study of ICFS*

After the appropriate mesh size was obtained by the mesh convergence and computational efficiency study, we had updated the calculation results and displacement cloud images.

In page 19, the figure 11 were updated. The old figure is as follows:



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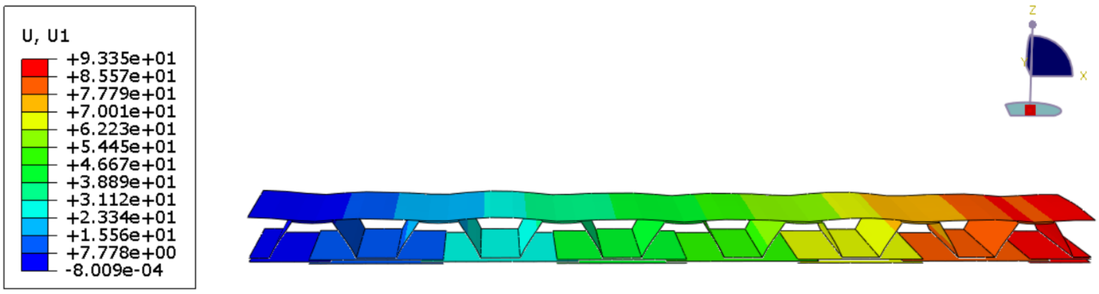

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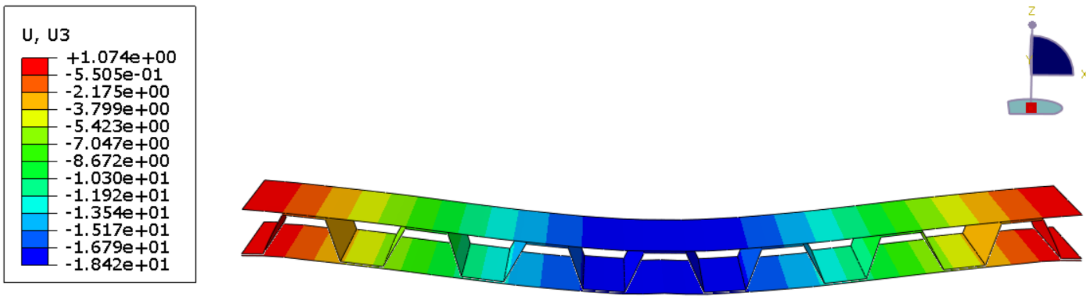
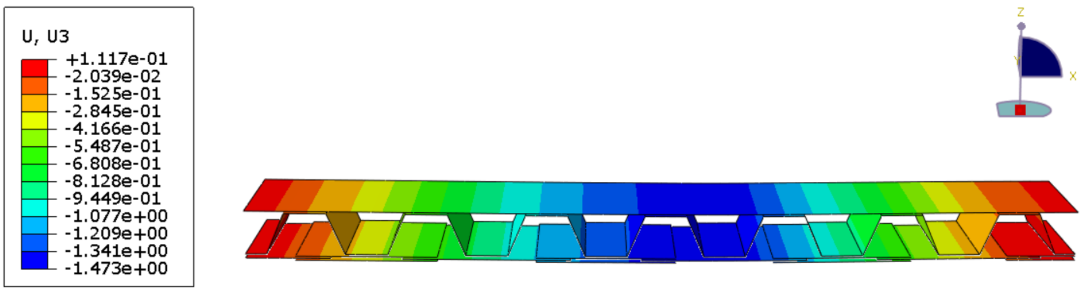


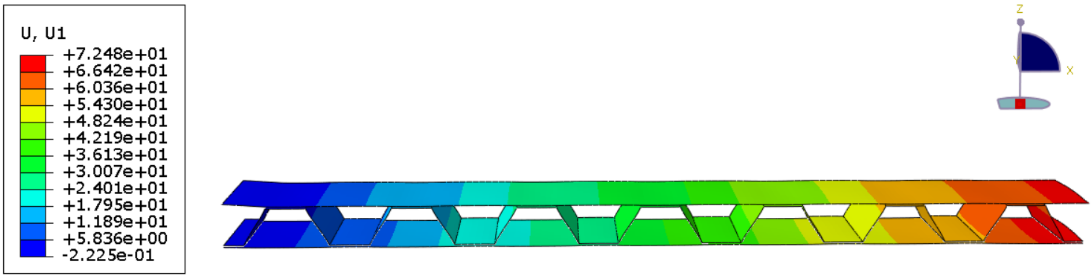
(c)



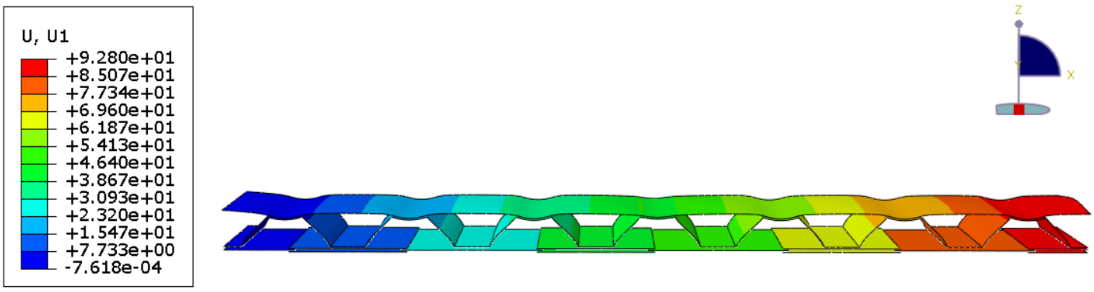
(d)

Figure 11. *The deformation of flexible skin: (a)Tensile deformation of the CCFS; (b) Tensile deformation of the ICFS; (c) Bending deformation of the CCFS; (d) Bending deformation of the ICFS*

The new figure is as follows:



(a)



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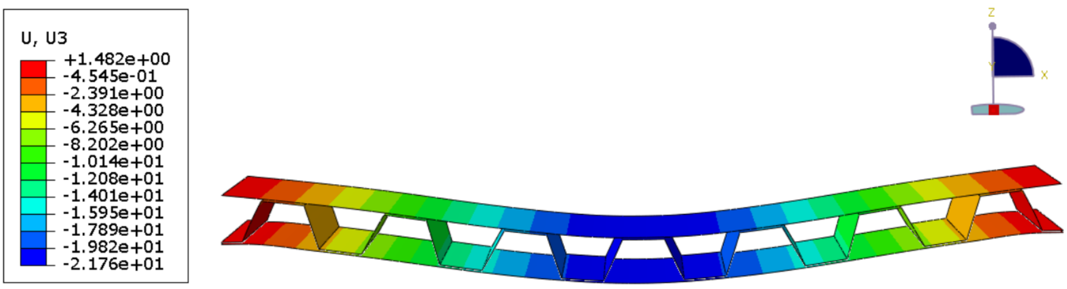

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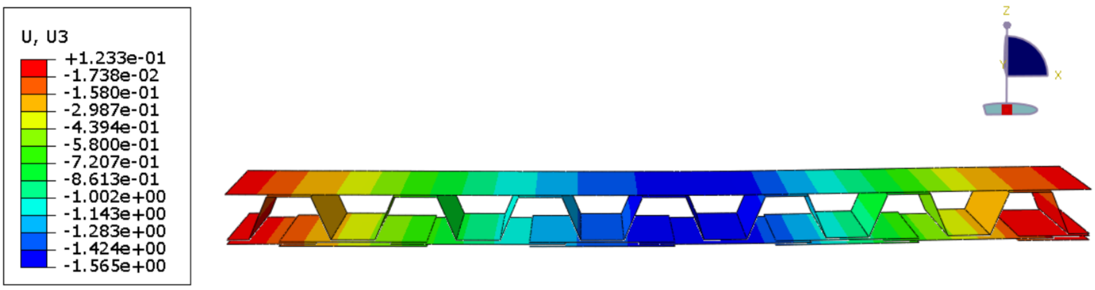


(d)

Figure 12. *The deformation of flexible skin: (a)Tensile deformation of the CCFS; (b)*

Tensile deformation of the ICFS; (c) Bending deformation of the CCFS; (d) Bending deformation of the ICFS

In page 18, the sentences " For the tensile condition, the maximum deformation of the ICFS is 93.350mm, which is about twice that of the CCFS." were changed to " For the tensile condition, the maximum deformation of the ICFS is 92.800mm, which is about 1.3 times that of the CCFS(72.480mm)."

In page 19, the sentences " For the bending condition, the maximum deformation of the ICFS is 1.473mm, which is about one eighteenth of the maximum deformation of the CCFS." were changed to " For the bending condition, the maximum deformation of the ICFS is 1.565mm, which is about 1/21 of the maximum deformation of the CCFS(21.760mm)."

Comment 6:

Page 16: F1=2 N and F2=0.005 N …Why? Please explain better the reason of these values of concentrated loads.

Response 6:

Firstly, we apologize that in the bending case we applied a uniform pressure of $P = 0.005\text{MPa}$ on the bonding area between the upper skin and the middle unit of the corrugated core, which was written as a concentrated load of $F_2 = 0.005\text{N}$ due to my clerical error. Based on the comment of the third reviewer, we have revised the relevant content.

And then, the reason for these values of loads ($F = 2N$, $P = 0.005MPa$) is explained as follows: The value of bending load applied on the flexible skin should be calculated by aerodynamic pressure of morphing aircraft during flight. In this paper, we referred to conclusions of relevant literature: the out-of-plane displacements due to air pressure loading should be kept below 1 mm[1], otherwise deflection on the upper surface of the flexible skin would cause detrimental effects on aerodynamic performances[2]. In order to verify the stiffness of flexible skin, the maximum deformation result should be slightly larger than the required value. Therefore, we have chosen $P = 0.005\text{MPa}$ as uniform pressure to simulate bending load so that the calculated deflection of improved corrugated flexible skin (ICFS) is 1.565mm. The value of tensile load applied on the flexible skin is related to the driving force which makes the lead edge of wing produce drooping movement. However, driver is not the subject of this article, so we take the allowable strain of rubber in flexible skin as the maximum deformation of the whole flexible skin. According to relevant literature, the maximum strain along the length direction of rubber should be kept below 10%, otherwise it would fail due to fatigue after several loading cycles[1]. To verify the tensile performance of flexible skin, we have chosen $F = 2N$ as value of tensile load so that the maximum strain of the CCFS along the length direction is 18%(Elongation divided by original length), which is slightly larger than this allowable stress value.

In page 16, we added relevant content: " The values of loads in tensile and bending case are mainly based on the following two principles: (1) The out-of-plane displacements due to air pressure loading should be kept below 1 mm[30], otherwise deflection on the upper surface of the flexible skin would cause detrimental effects on aerodynamic performance[3]. (2) The maximum strain along the length direction of rubber should be kept below 10%, otherwise it would fail due to fatigue after several loading cycles[30]. "

[1] Schorsch O, Nagel C and Lühring A. *Book. Chapter 7 - Morphing Skin: Foams,* 2018, Butterworth-Heinemann (Chapter 7 - Morphing Skin: Foams 207-230)

[2] Airoldi A, Fournier S, Borlandelli E, Bettini P and Sala G. Design and manufacturing of skins based on composite corrugated laminates for morphing aerodynamic surfaces, *Smart Mater Struct,* 2017, 26:

Comment 7:

Section 2.4: Why are FE models and experimental samples different? (in terms of geometry, amount of units…). It would be interesting to compare the results in order to carry out a numerical/experimental correlation.

Response 7:

This is a valuable suggestion, thanks for the help. But it is a pity that our rubber supplier has failed to provide relevant mechanical properties parameters of rubber to simulate its non-linear stress-strain behaviour, so we lack the basis for accurately simulation of mechanical behaviour of flexible skins. Therefore, we only design the improved corrugation flexible skin(ICFS) through numerical simulation, and verify its flexibility in the corrugation direction and the load bearing capacity in the direction perpendicular to corrugation through lateral comparison of experiments. In the next phase of the work(research on flexible skin with longer spanwise length), we will cooperate with rubber suppliers who can provide complete mechanical properties parameters of rubber, conduct numerical simulations with taking geometry and material nonlinearity into account, and compare results with experimental data.

Comment 8:

Table 4 and 6: please check the order of load cases to help the reading comprehension.

Response 8:

In order to facilitate the reader's understanding, we have adjusted the corresponding table.

In page 17, the table 4 is changed. The old table is as follows:

Table 4. *Load cases and results of simulation*

Load cases	Object	Magnitude of load	Deformation
Tensile	The CCFS	2.000N	52.080mm
Tensile	The ICFS	2.000N	93.350mm
Bending	The CCFS	0.005N	18.420mm
Bending	The ICFS	0.005N	1.473mm

The new table is as follows:

Table 4. *Load cases and results of simulation*

FEM No.	Object	Load cases	Magnitude of load	Deformation
1	The CCFS	Bending	0.005MPa	21.760mm
2	The ICFS	Bending	0.005MPa	1.565mm
3	The CCFS	Tensile	2.000N	72.480mm
4	The ICFS	Tensile	2.000N	92.800mm

In page 23, the table 6 is changed. The old table is as follows:

Table 6. *Load cases and results*

No.	Load cases	Specimens	Weights	Deformation
1	Bending	The CCFS	100g×1	10mm
2	Bending	The ICFS	100g×1	2mm
3	Tensile	The CCFS	1000g×1	22mm
4	Tensile	The ICFS	1000g×1	29mm

The new table is as follows:

Table 7. *Load cases and results*

Exp. No.	Specimens	Load cases	Weights	Deformation
1	The CCFS	Bending	100g×1	10mm
2	The ICFS	Bending	100g×1	2mm
3	The CCFS	Tensile	1000g×1	22mm
4	The ICFS	Tensile	1000g×1	29mm

Comment 9:

Page 28: "…there is the deviation between the reference profile and the actual shape of the ICFS after deflection." Possible solutions?

Response 9:

In order to verify tensile ability of the improved corrugated flexible skin(ICFS) in traditional drooping leading edge application and whether it can affect the deflection angle, we have designed the movement functional experiment. In this experiment, we used the ICFS to replace a part of the upper skin in the traditional drooping leading edge, and investigated whether the leading edge would fit the reference shape. It was found that under the action of driving force, there was local deformation appeared in ICFS and this caused a certain deviation between the reference profile and the actual shape of the ICFS after downward deflection. This phenomenon has nothing to do with the bending stiffness of the ICFS which is not subjected to aerodynamic loads in this experiment, but is caused by the influence of the position, size and way of the driver on the local deformation of the flexible skin. Therefore, the coupling effect between the skin deformation and the position, size and way of the driver should be considered when applying ICFS to the actual drooping leading edge design of morphing aircraft. This part of the research work will be carried out in the next stage.

We added relevant content.

In page 26, we added the sentences: " And based on the purpose of verifying the stretching ability of the improved corrugated flexible skin(ICFS) and whether it can affect the deflection angle of the drooping leading edge, we have designed the movement functional experiment through 3D technology."

In page 30, we added the sentences: " This phenomenon is caused by the influence of the position, size and way of the driver on the local deformation of the flexible skin. Therefore, the traditional design method of droop leading edge without consideration of driver effect is no longer applicable, and a new design method based on skin deformation and driver coupling needs further study in the future."

Comment 10:

It would be beneficial to discuss more specifically in the Conclusion Section possible future works that could make it particularly interesting for further actual applications (e.g., better explanations of further research in the last part of the section…).

Response 10:

In page 31, we added the relevant contents: "Better explanations of further research in the last part of the section are as follows: For further actual application of the improved corrugated flexible skin(ICFS), it is necessary to conduct more accurate numerical simulations with taking geometry and material nonlinearity into account. When the ICFS is used to replace a certain length upper skin of the drooping leading edge, the deformation should be studied by applying real aerodynamic loads on the upper surface. Aiming at the coupling problem of actuator and local deformation of flexible skin, coupling design based on distributed drive may be an effective solution. Whether this driving system by placing drivers in multiple position and coordinating with each other to realize downward deflection function of the drooping leading edge can effectively alleviate the local deformation of the ICFS is focus of future work."

Reply to Reviewer3

Thank you very much for your time in reviewing the paper and valuable feedback. And, in the following sections we answered these questions.

Comment 1:

The unit schemes of corrugated flexible skin for analytical modelling considered without upper panel has essentially different mechanical properties comparing to the real (full) unit of corrugated flexible skin, especially in the case of bending loading. The authors could present more arguments why it was considered to do not take into account the upper panel.

Response 1:

It is true that the presence or absence of the upper panel have a certain degree of influence on stiffness calculation of the flexible skin analytical model. During the improvement of the corrugated flexible skin, only the lower skin was replaced, and the upper skin remained unchanged. Therefore, to simplify the analytical model used to compare the stiffness change before and after the improvement, we mainly considered the effect of the lower panel, while the upper panel will be considered in the numerical simulation.

In page 8, we added the relevant contents: "During the improvement of the corrugated flexible skin, only the lower skin was replaced, and the upper skin remained unchanged. Therefore, to simplify the analytical model used to compare the stiffness change before and after the improvement, we mainly considered the effect of the lower panel, while the upper panel will be considered in the numerical simulation."

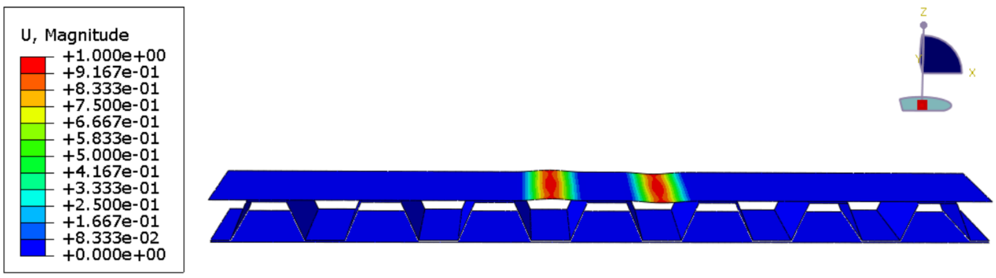
Comment 2:

During the bending load the upper panel of the skin is compressed and the buckling has to be evaluated or at least discussed, specially when the authors confirm that proposed analytical model can be applied for the determination of geometrical parameters. The same could be adapted to the flow chart of the requirements for the flexible skin.

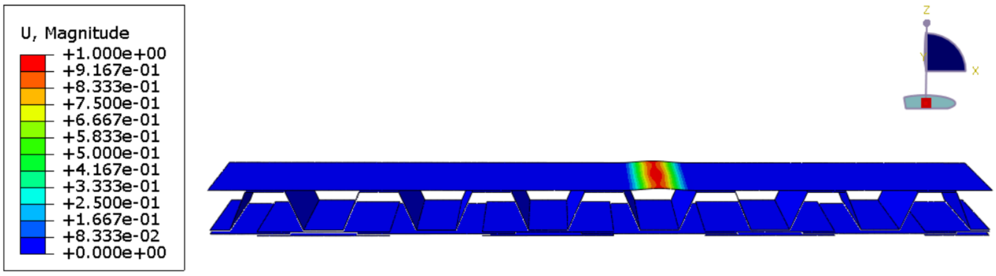
Response 2:

We performed linear buckling analysis for two kinds of flexible skins and added relevant content in the sections of numerical simulation, experiment and application procedure respectively.

In page 20, we added the contents: "In addition, during the bending case the upper panel of the corrugated flexible skin is compressed and the buckling has to be evaluated. Similarly, the linear buckling analysis for two types of flexible skins is performed by the finite element software Abaqus and the relevant geometric and property parameters are consistent with the finite element model for static analysis. The results are shown in Fig. 12, through the numerical simulation analysis, the critical buckling pressure of the CCFS is 3.63×10^{-4}MPa, and that of the ICFS is 2.49×10^{-3}MPa. "



(a)



(b)

Figure 13. *The linear buckling analysis of flexible skin in bending case: (a) The Buckling analysis of the CCFS; (b) The buckling analysis of the ICFS;*

In page 24, we added the contents: " In addition, it is necessary to consider the buckling of the upper panel on two kinds of flexible skins in the bending case. In experiment 1, it can be observed that the buckling deformation occurs at both sides of upper panel on the middle-corrugated unit of the CCFS, this phenomenon is consistent with the results of numerical simulation. In experiment 2, the bucking deformation appears on the right side in the middle of the upper panel of the ICFS, and this result is slightly different from the numerical simulation. The reason is that geometric parameters, material properties and the number of corrugated units are different between the experiment and the numerical simulation. "

In page 25, we added the contents: " In particular, the buckling deformation is a typical phenomenon that affects local stiffness of flexible skin, and it is necessary to conduct buckling analysis when the design of ICFS is finished. "

In page 25, the sentences: " According to the flow chart (Fig. 17), the design process of the ICFS can be composed of four steps." were changed to " According to the flow chart (Fig. 17), the design process of the ICFS can be composed of five steps."

In page 25, we added the fifth step to the design process of ICFS: " (5) Once the ICFS design is completed, a buckling analysis needs to be performed to check its local load carrying capacity. "

In page 26, the corresponding figure was changed. The old figure is as follows:

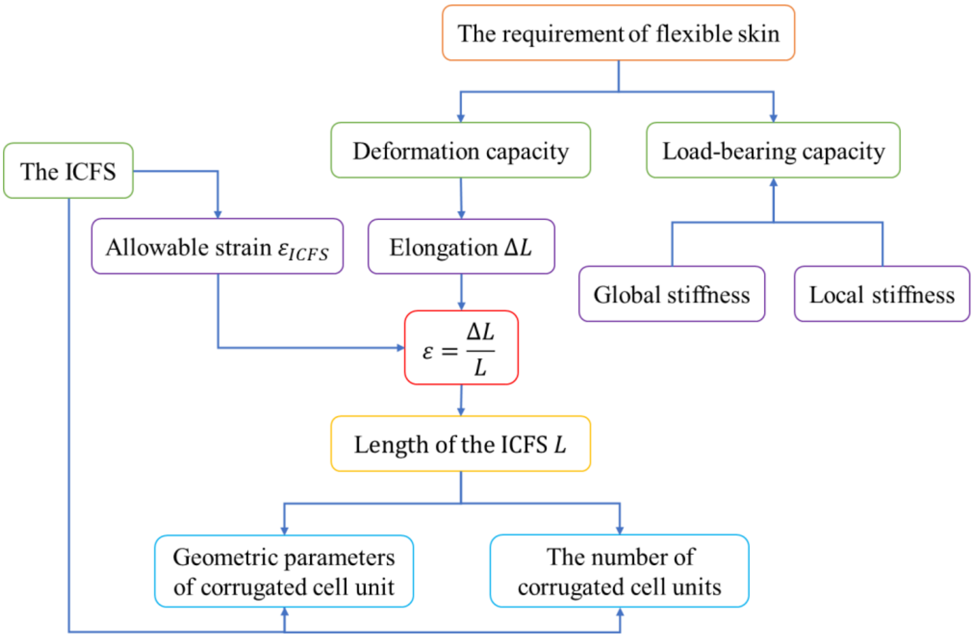


Figure 17. *Flow chart of application procedure*

The new figure is as follows:

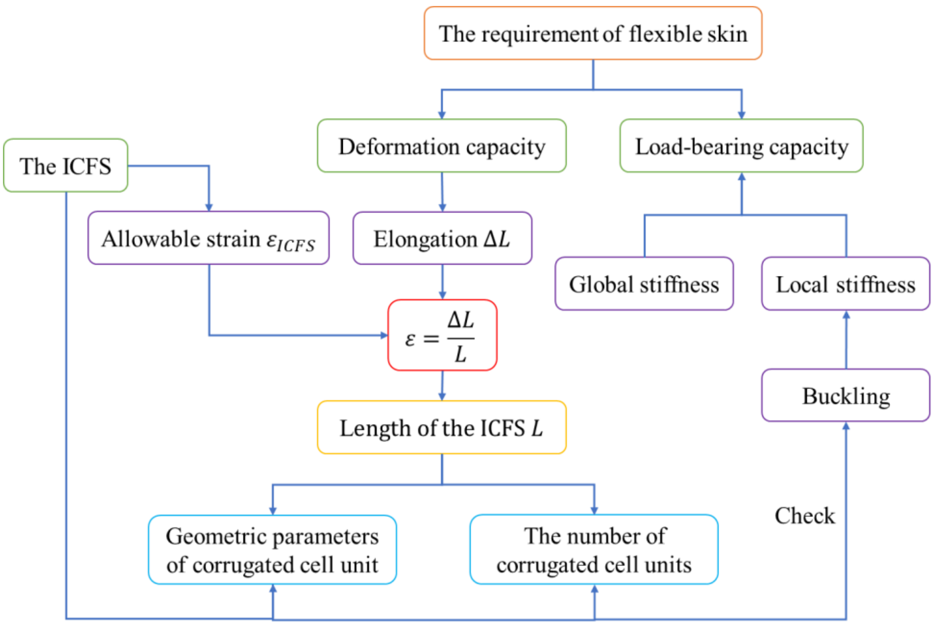


__Figure 19.__ Flow chart of application procedure

Comment 3:

There was used three different approaches analytical, numerical and experimental and it looks that it could be very useful for the validation of the proposed analytical model, but for each approach authors choose to use different geometrical parameters which prevents to prove the eligibility of analytical model. The results would be more valuable if the geometrical parameters of analytical and numerical models would correspond to the experimental model.

Response 3:

This is a valuable suggestion, thanks for the help. But it is a pity that our rubber supplier has failed to provide relevant mechanical properties parameters of rubber to simulate its non-linear stress-strain behaviour, so we lack the basis for accurately simulation of mechanical behaviour of flexible skins. Therefore, we only design the improved corrugation flexible skin(ICFS) through numerical simulation, and verify its flexibility in the corrugation direction and the load bearing capacity in the direction perpendicular to corrugation through lateral comparison of experiments. In the next phase of the work(research on flexible skin with longer spanwise length), we will cooperate with rubber suppliers who can provide complete mechanical properties parameters of rubber, conduct numerical simulations with taking geometry and material nonlinearity into account, and compare results with experimental data.

Comment 4:

Chapter 1.0 Introduction "To satisfy these conflicting requirements, many designs ….".

Response 4:

In page 2, the sentences:" To satisfy these conflicting requirements, many deigns of flexible skin are proposed, and Thill gave a comprehensive review of flexible skins and corresponding material system[10]." were changed to:" Therefore, the requirements for flexible skin are conflicting, for this problem, many deigns of flexible skin were proposed. Thill gave a comprehensive review of flexible skins and corresponding material system[10]. "

Comment 5:

Chapter 2.2 "cin(alpha)" - cos(alpha).

Response 5:

In page 9, the sentences:" Moreover s and c denote $sin\alpha$ and $cin\alpha$ respectively." were changed to: " Moreover s and c denote $sin\alpha$ and $cos\alpha$ respectively."

Comment 6:

In eq. (12) "w" not explained.

Response 6:

In page 10, we added the sentences: "Where l, w represent length and width of a corrugated unit respectively."

Comment 7:

In eq. (13) and (18) "w" used superscripts "1" and "2", while in other places "t" and "b".

Response 7:

In page 11, Eq. (13) is modified. The old content is as follows:

$$\begin{cases} U_{AB}^{t} = \frac{(g-f)^2 a_3}{E_1 A_1}, & U_{AB}^{b} = \frac{(M+gh-fh)^2 a_3}{E_1 I_1} \\ U_{AC}^{t} = U_{BD}^{t} = \frac{(g-f)^2 a_2 s}{2E_1 A_1}, & U_{AC}^{b} = U_{BD}^{b} = \frac{a_2\left(a_2^2 c^2 (g-f)^2 + 3a_2 cMs(g-f) + 3M^2 s^2\right)}{6E_1 I_1 s^3} \\ U_{OC}^{2} = \frac{M^2 a_1}{E_1 I_1}, & U_{DE}^{2} = \frac{M^2 a_1}{E_1 I_1} \end{cases} \quad (13)$$

The new content is as follows:

$$\begin{cases} U_{AB}^{t} = \frac{(g-f)^2 a_3}{E_1 A_1}, & U_{AB}^{b} = \frac{(M+gh-fh)^2 a_3}{E_1 I_1} \\ U_{AC}^{t} = U_{BD}^{t} = \frac{(g-f)^2 a_2 s}{2E_1 A_1}, & U_{AC}^{b} = U_{BD}^{b} = \frac{a_2\left(a_2^2 c^2 (g-f)^2 + 3a_2 cMs(g-f) + 3M^2 s^2\right)}{6E_1 I_1 s^3} \\ U_{OC}^{b} = \frac{M^2 a_1}{E_1 I_1}, & U_{DE}^{b} = \frac{M^2 a_1}{E_1 I_1} \end{cases} \quad (13)$$

In page 12, Eq. (18) is also modified. The old content is as follows:

$$U_{OCABDE} = U_{BD}^{1} + U_{AC}^{1} + U_{AB}^{1} + U_{OC}^{2} + U_{AC}^{2} + U_{AB}^{2} + U_{BD}^{2} + U_{DE}^{2} \quad (18)$$

The new content is as follows:

$$U_{OCABDE} = U_{BD}^t + U_{AC}^t + U_{AB}^t + U_{OC}^b + U_{AC}^b + U_{AB}^b + U_{BD}^b + U_{DE}^b \quad (18)$$

Comment 8:

Chapter 2.3 Is it really the concentrated force of 0.005 N magnitude gives the deformations of 18 mm?

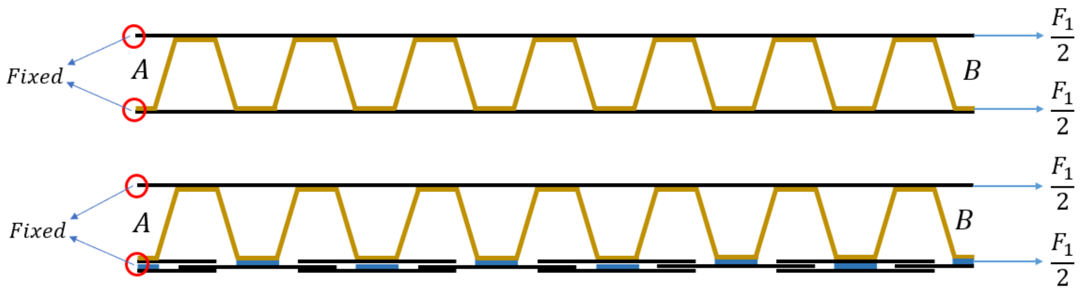
Response 8:

Thanks for your reminder, we apologize that in the bending case we applied a uniform pressure of $P = 0.005\text{MPa}$ on the bonding area between the upper skin and the middle unit of the corrugated core, which was written as a concentrated load of $F_2 = 0.005\text{N}$ due to my clerical error. Accordingly, we have modified the relevant content.

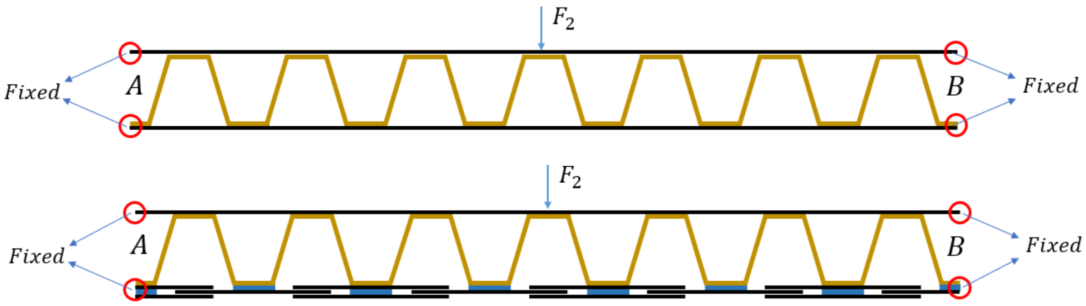
In page 16, the sentences " In tensile case, the left end (A) of the structure is fixed and a force(F_1=2.000N) along the corrugation direction is applied on the right end(B)." were changed to " In tensile case, the left end (A) of the structure is fixed and a force(F=2.000N) along the corrugation direction is applied on the right end(B)."

In page 16, the sentences "In bending case, both left and right ends of the structure is fixed and a concentrated force of 0.005N along the vertical downward direction at the middle of upper panel is applied." were changed to " In bending case, both left and right ends of the structure is fixed and a uniform pressure of $P = 0.005\text{MPa}$ is applied in the bonding area between the upper skin and the middle unit of the corrugated core."

In page 17, figure 10 was changed. The old figure is as follows:



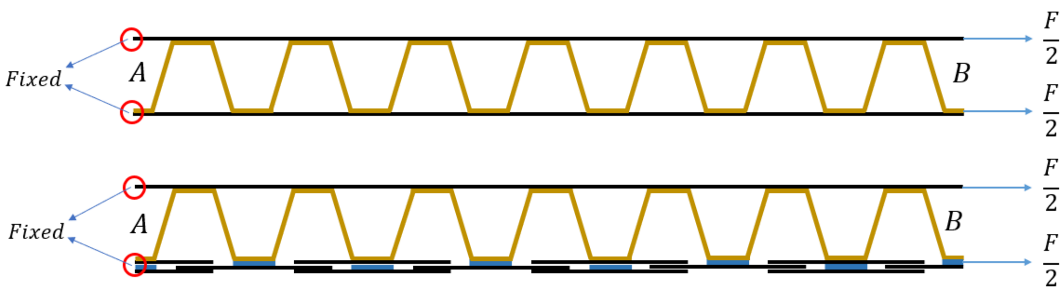
(a)



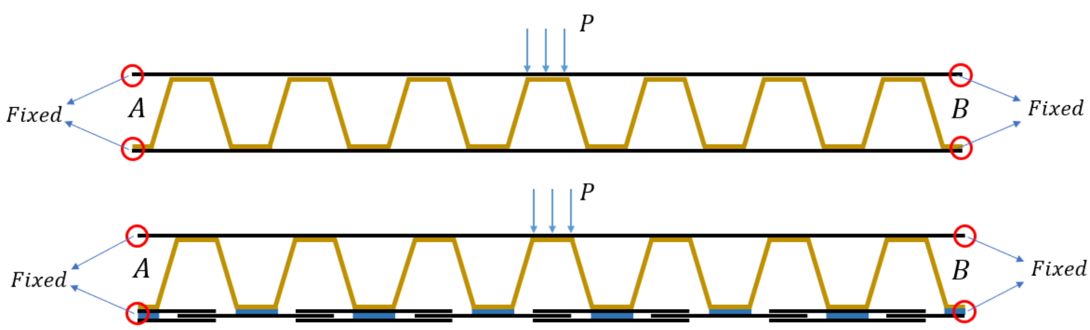
(b)

Figure 10. *Load cases: (a)Tensile; (b)Bending*

The new figure is as follows:



(a)



(b)

Figure 10. *Load cases: (a)Tensile; (b)Bending*

In page 17, table 4 was changed. The old table is as follows:

Table 4. *Load cases and results of simulation*

FEM No.	Object	Load cases	Magnitude of load	Deformation
1	The CCFS	Bending	0.005N	21.760mm
2	The ICFS	Bending	0.005N	1.565mm
3	The CCFS	Tensile	2.000N	72.480mm
4	The ICFS	Tensile	2.000N	92.800mm

The new table is as follows:

Table 4. *Load cases and results of simulation*

FEM No.	Object	Load cases	Magnitude of load	Deformation
1	The CCFS	Bending	0.005MPa	21.760mm
2	The ICFS	Bending	0.005 MPa	1.565mm
3	The CCFS	Tensile	2.000N	72.480mm
4	The ICFS	Tensile	2.000N	92.800mm

Comment 9:

Figure 19. "defetion" - deflection?

Response 9:

In page 27, we replaced the corresponding figure. The old figure is as follows:

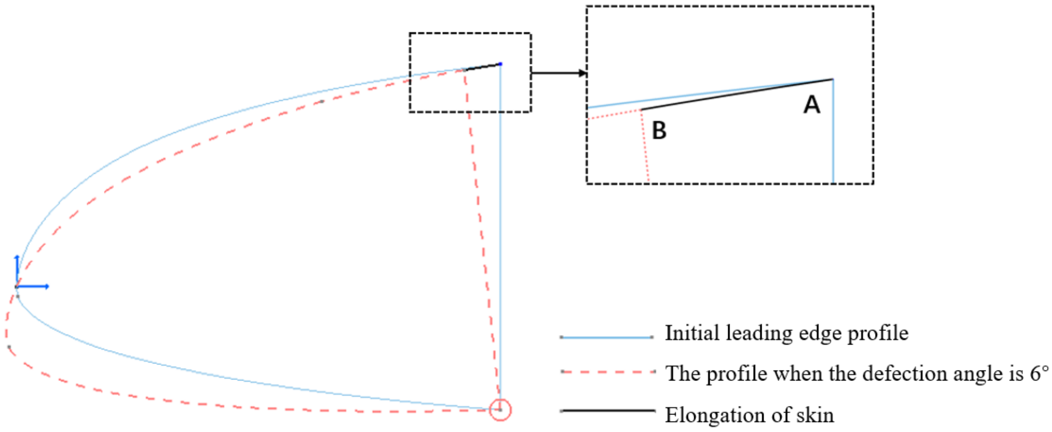


Figure 19. *Measurement of skin elongation*

The new figure is as follows:

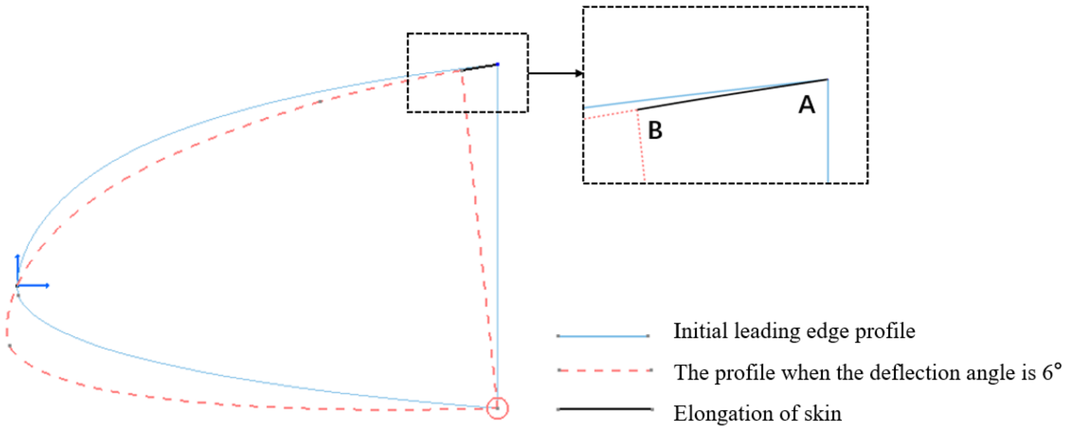


Figure 21. *Measurement of skin elongation*