

# Numerical Analysis using the QBlade(Ver.0.8) with wind turbine paper model Basic Manual *Beta* ver.

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<http://www.kobe-kosen.ac.jp/~waseda/wtgpapermodel/index.html>にある作品に基づいている。

このライセンスで許諾される範囲を超えた利用の可能性については以下のアドレスもご覧下さい。

<http://www.kobe-kosen.ac.jp/~waseda/wtgpapermodel/index.html>

**Caution!!**

**The purpose of the education tools is not full-fledged HAWT development but get a big picture view of HAWT development. Do not desire the accuracy of paper model experiment and analysis method.**

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**2017 Waseda Lab.**

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## **Preparation**

# I Analysis of the symmetrical blade

## 1. Obtaining data samples

### (1) Preparation

- Paper craft Wind turbine
- Fan
- Convex
- Plastic tape  
Mark every 0.25[m] between 0.75[m]~1.25[m].
- Tachometer (contactless)  
Put a reflecting sheet on the axis
- Anemometer
- scanner or digital camera

### (2) Instructions

#### (a) Measuring the wind speed

- Measure the wind speed in every length, air strength and take the average.

風速 - 計測値

		弱	中	強
0.75	下			
	中			
	上			
1.00	下			
	中			
	上			
1.25	下			
	中			
	上			

風速-平均值

	弱	中	強
0.75			
1.00			
1.25			

- Measure the wind speed in front side and back side of the fan in every length, air strength and take the average.

風速 - 測定値

		弱		中		強	
		前	後	前	後	前	後
0.7	下						
	中						
	上						
1.0	下						
	中						
	上						
1.2	下						
	中						
	上						

風速-平均値

	弱		中		強	
	前	後	前	後	前	後
0.75						
1.00						
1.25						

(b) Calculate the reduction ratio

- Calculate the reduction ratio using the next equation.

$$\text{減速比} = \frac{\text{風車前の風速}}{\text{風車なしの風速}} (\leq 1.0)$$

減速比

	弱	中	強
0.75			
1.00			
1.25			
平均			

(c) Measure the revolution speed

- Measure the revolution speed on every length and wind strength.

回転数-測定値

	弱	中	強
0.75			
1.00			
1.25			

(d) Calculate the Reynolds number

Substitute the result calculated in (a), (b), (c) using the spread sheet software and calculate the Reynolds number.

## 2. Designing the blade form

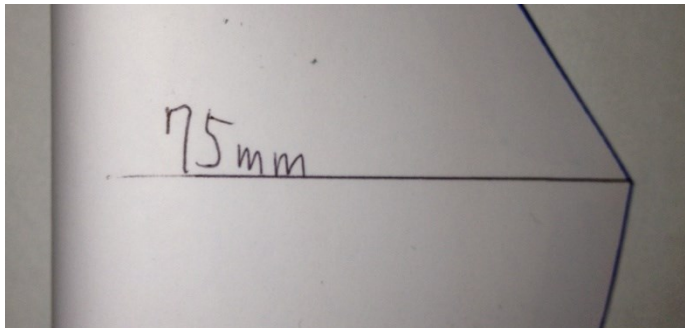
(1) Preparation

- Wire tie (at least 150mm)
- Plastic tape

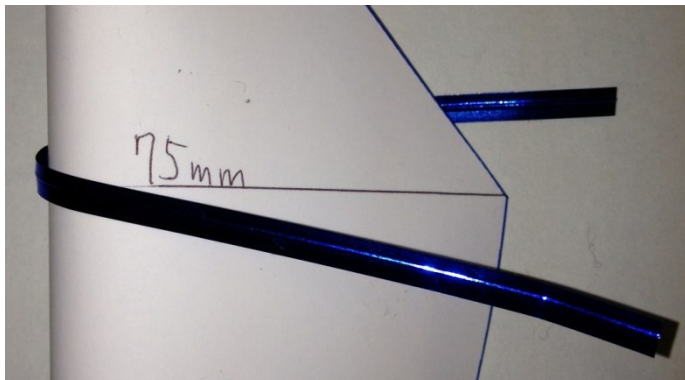
(2) Designing

(a) Mark where you design the air foil.

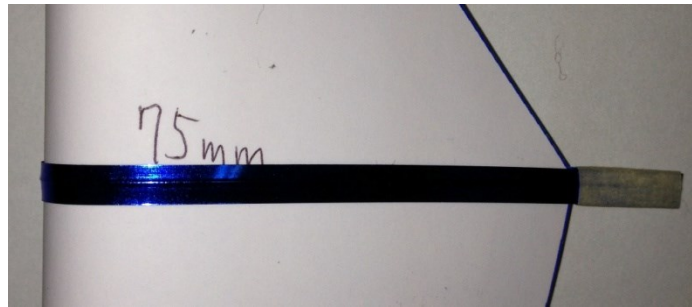
(The length shown below is a length from the center. This is an example.)



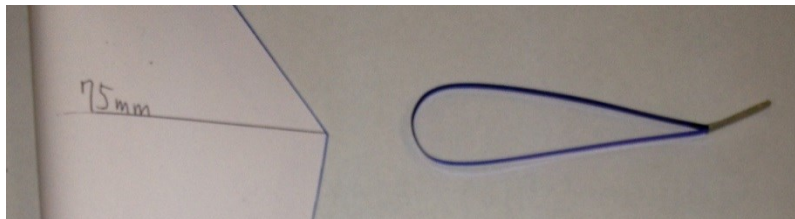
(b) Wrap the wire tie.



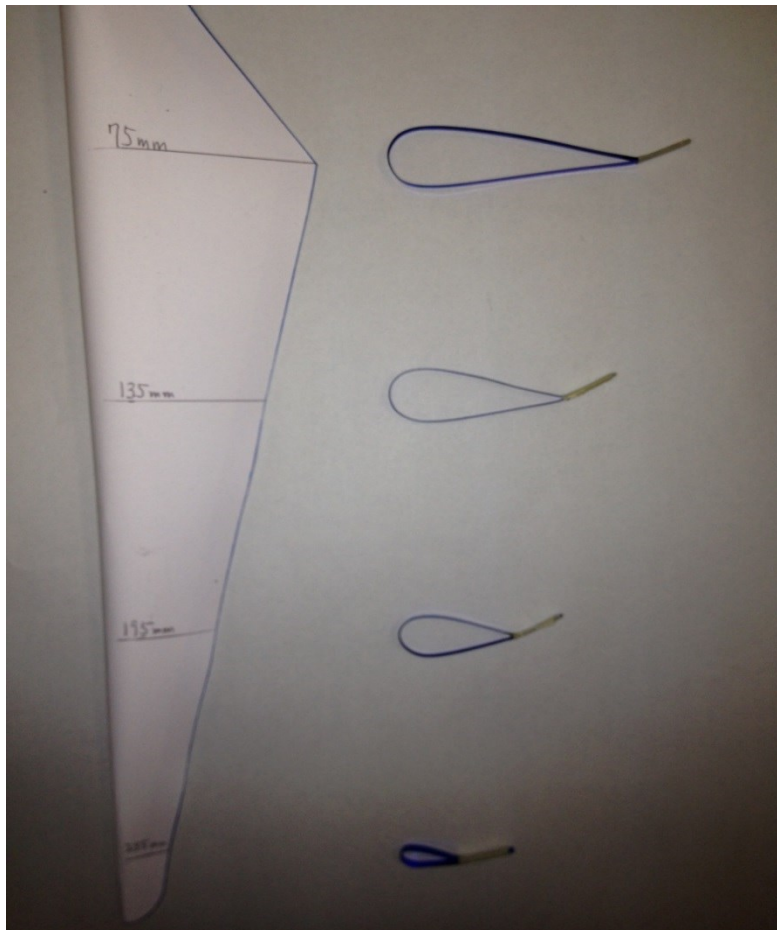
(c) Wrap along the blade form and lock it with a plastic tape.



(d) Remove the wire tie.



(e) Design the other blade forms if needed.



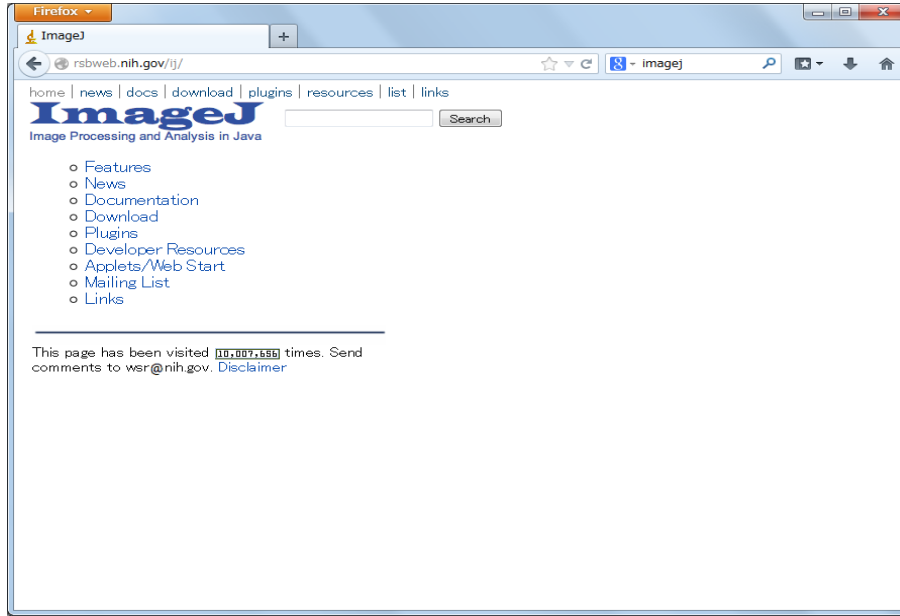
(f) Save the image in the computer using scanners or digital cameras.



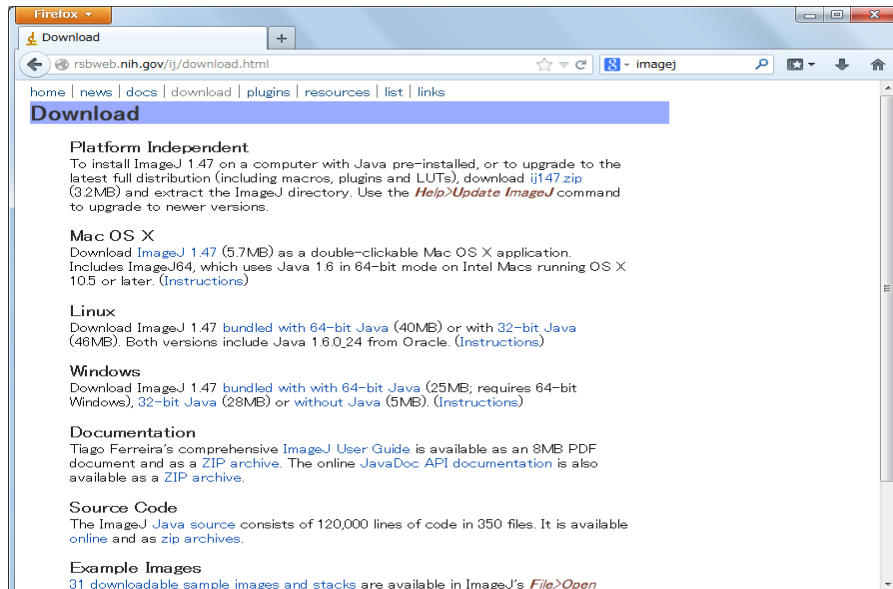
### 3. Preparation of the software

#### (1) Image J

##### (a) Look up “Image J” on the web and choose “Image J”

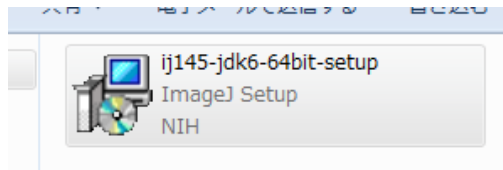


##### (b) Click “Download”.



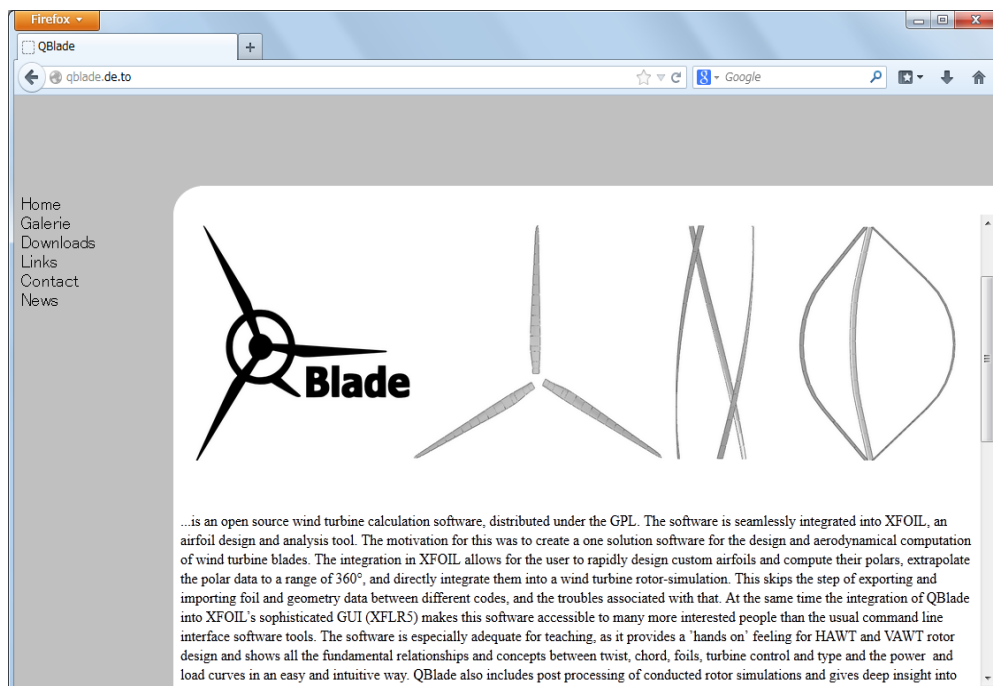


(c) Install “Image J” according to the install wizard.

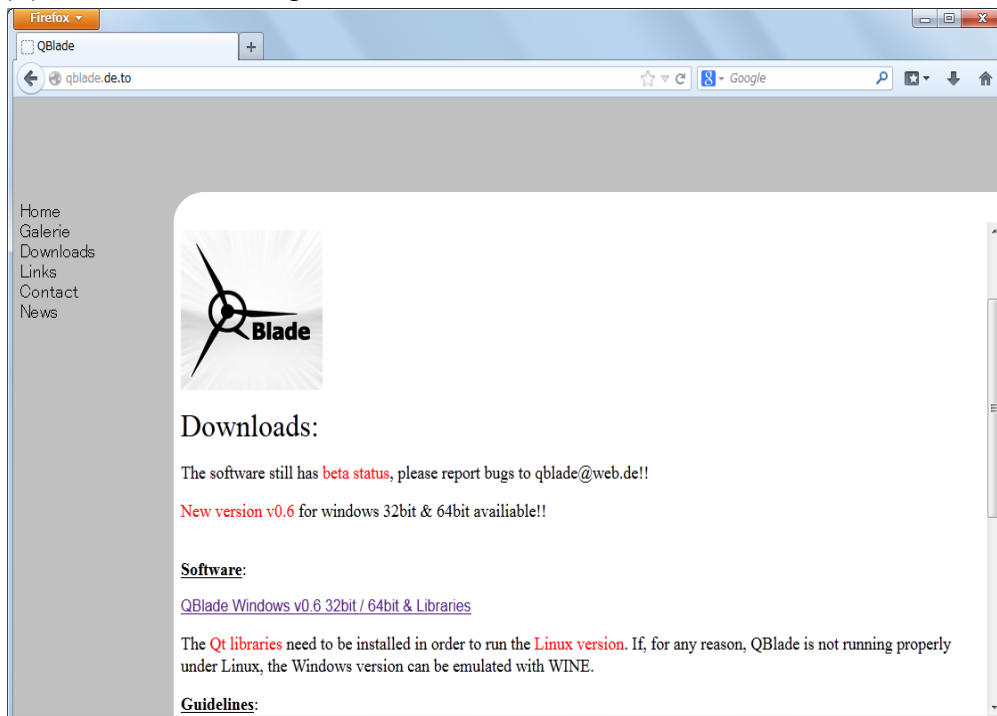


(2) Q Blade

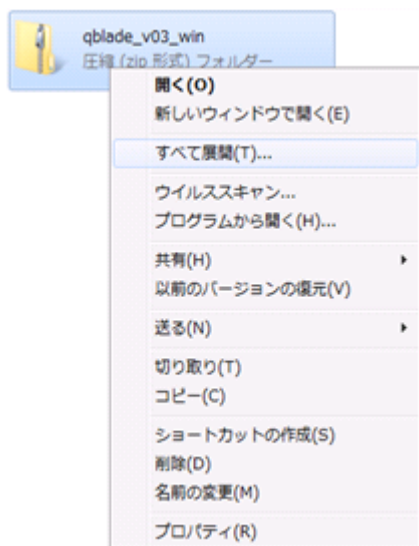
(a) Look up “Q Blade” on the web and choose “Q Blade”.



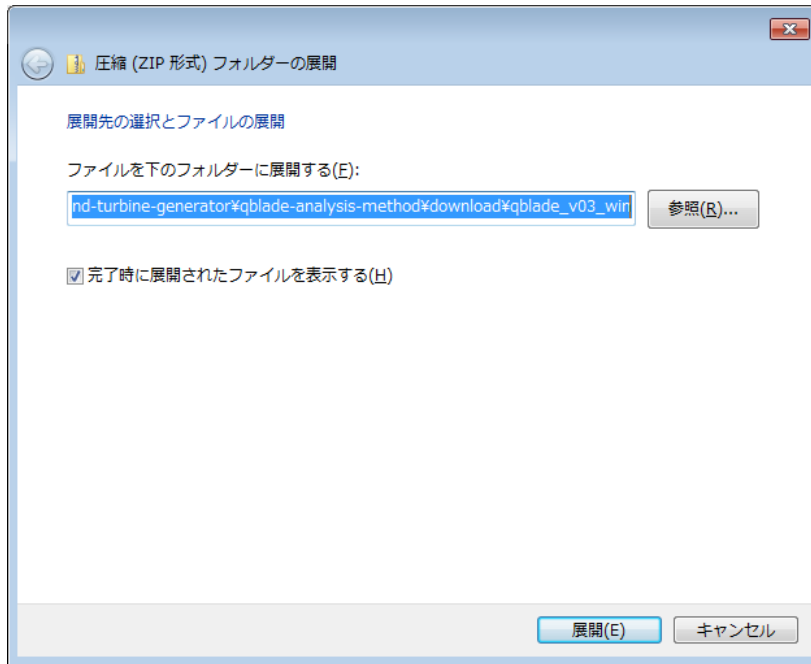
(b) After downloading, choose save.



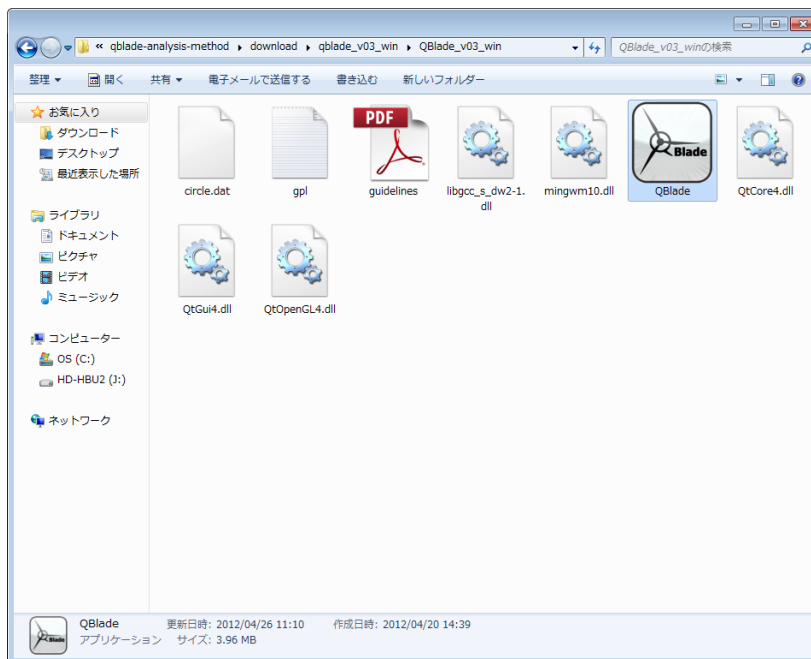
(c) Choose all unfold.



(d) Choose unfold.



(e) Download finished.

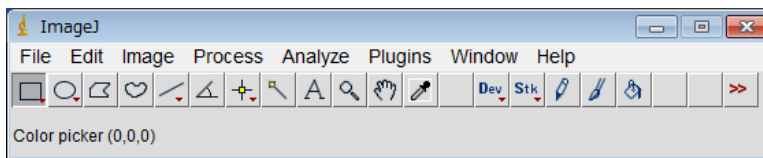


## 4. Creating analyze image

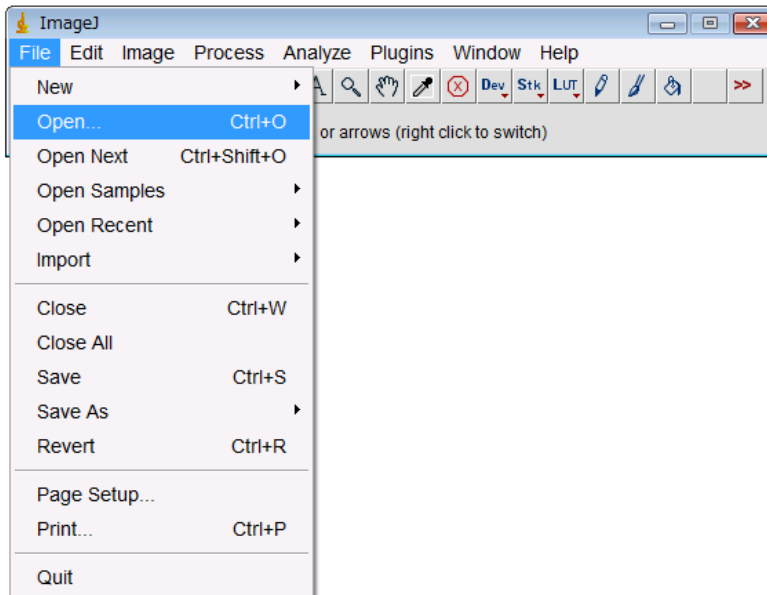
(1) Activate Image J.



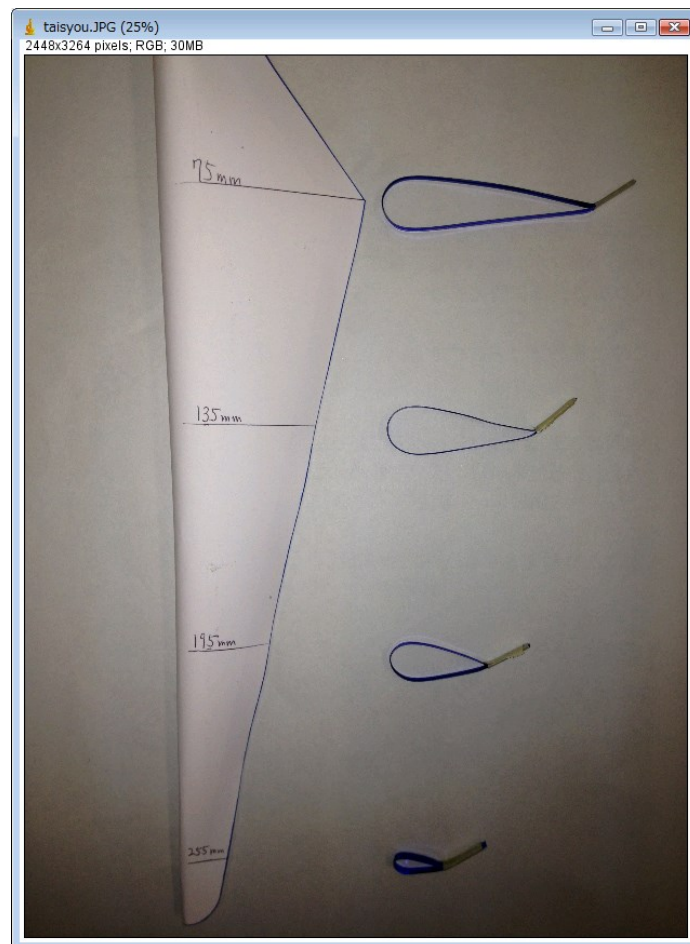
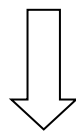
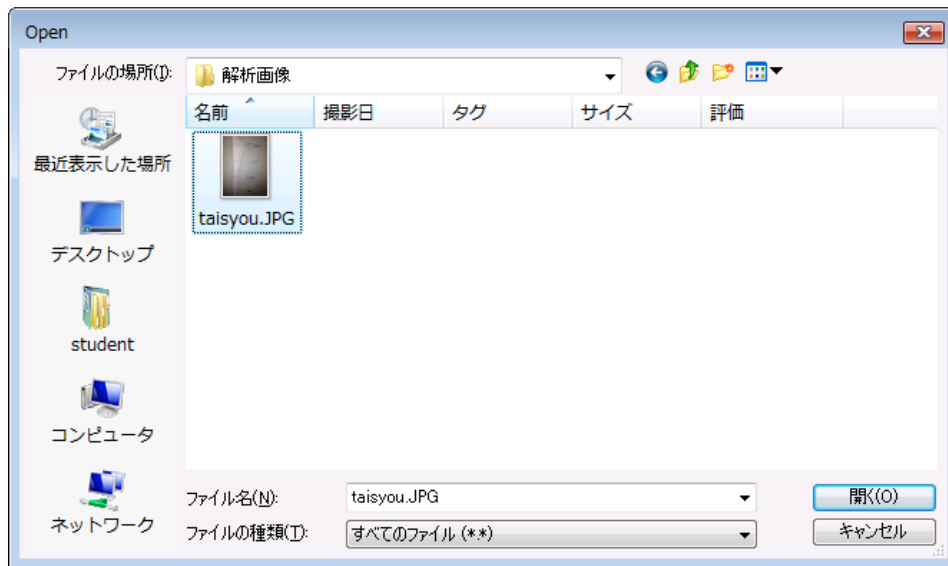
**Double Click**



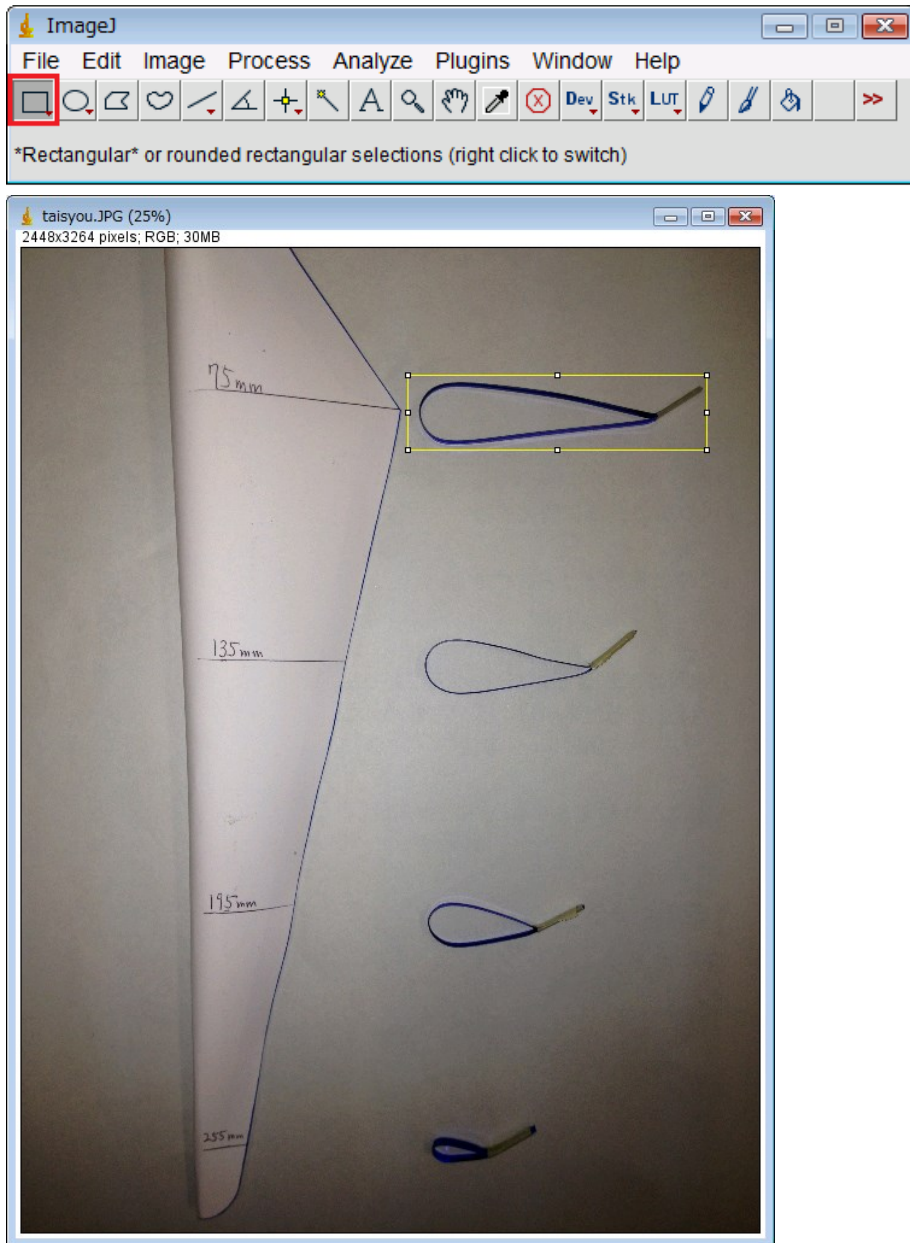
(2) Click File → Open.



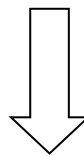
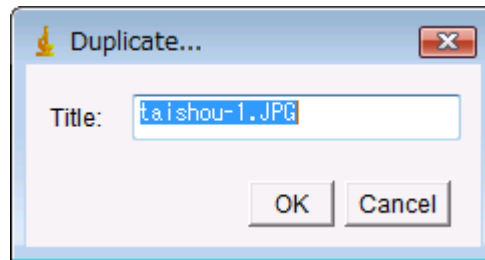
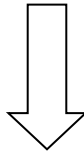
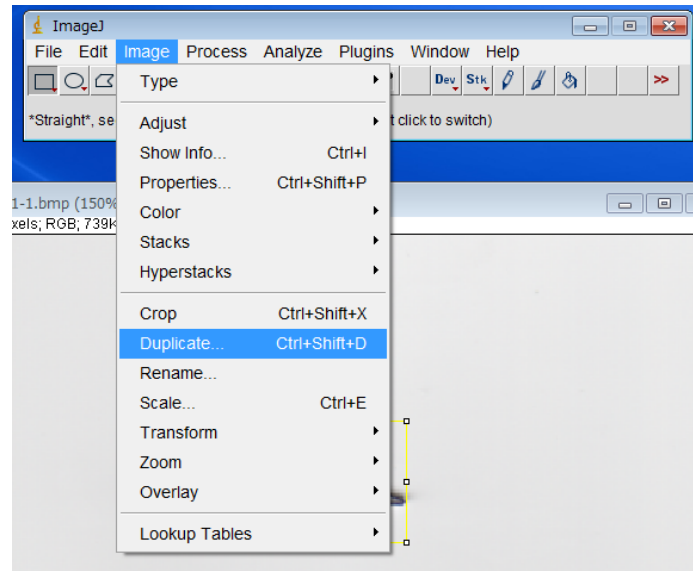
(2) Choose the image saved in I -2-(f).



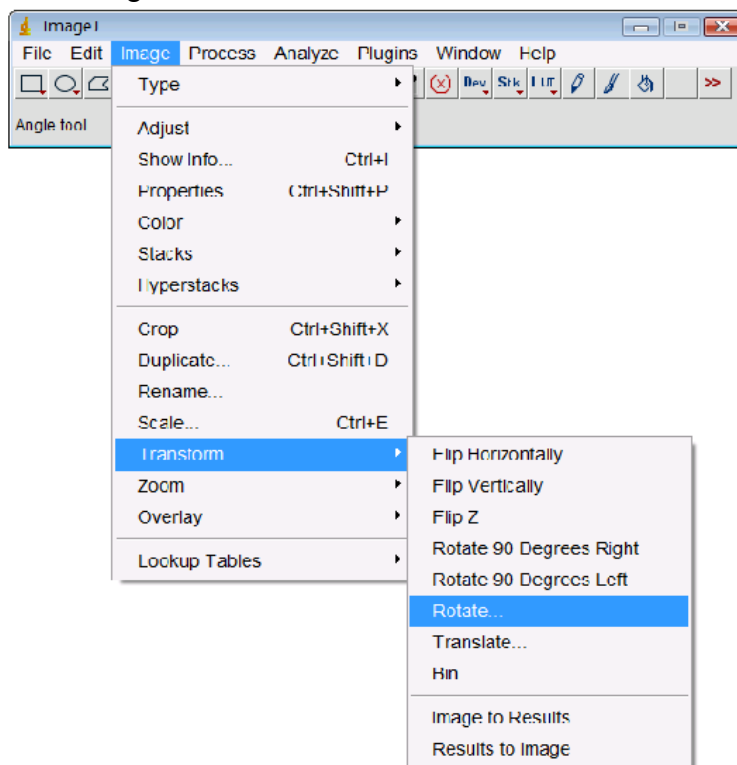
(3) Choose the rectangular tool and choose the whole blade shape like the picture below.



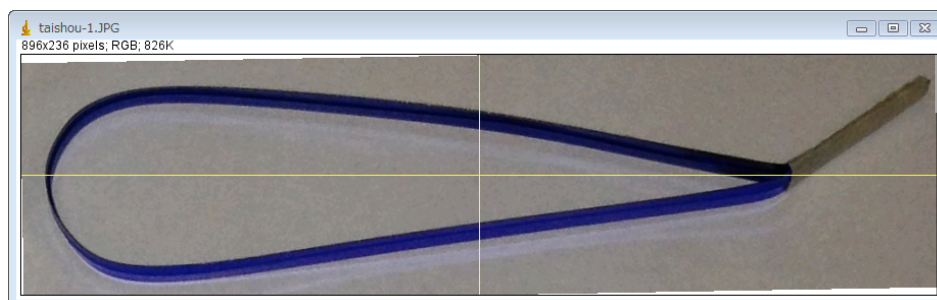
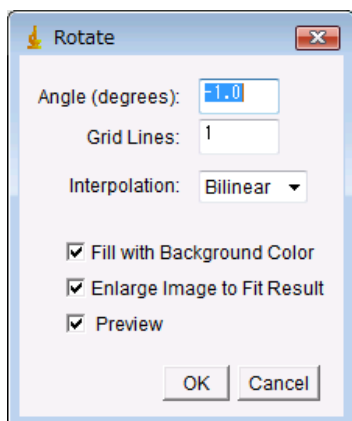
(4) Choose Image → Duplicate and click OK.



- If it wasn't scanned parallel, rotate the image.
- Click Image → Transform and choose Rotate.

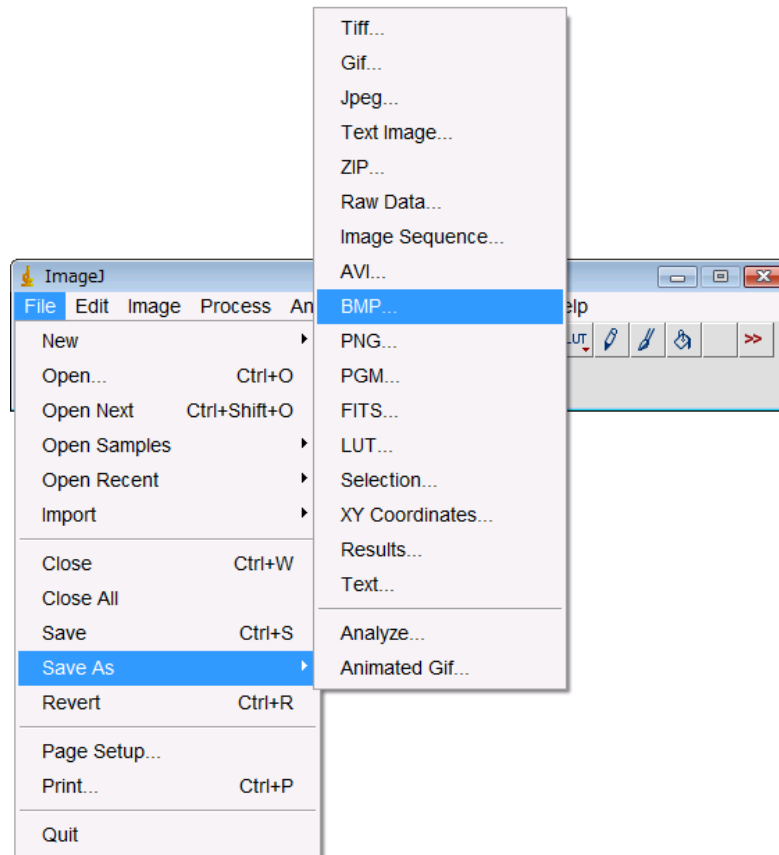


- Type in the angle.





(5) Click File→ Save As and choose BMP and save the file.  
(ex. taishou.bmp)

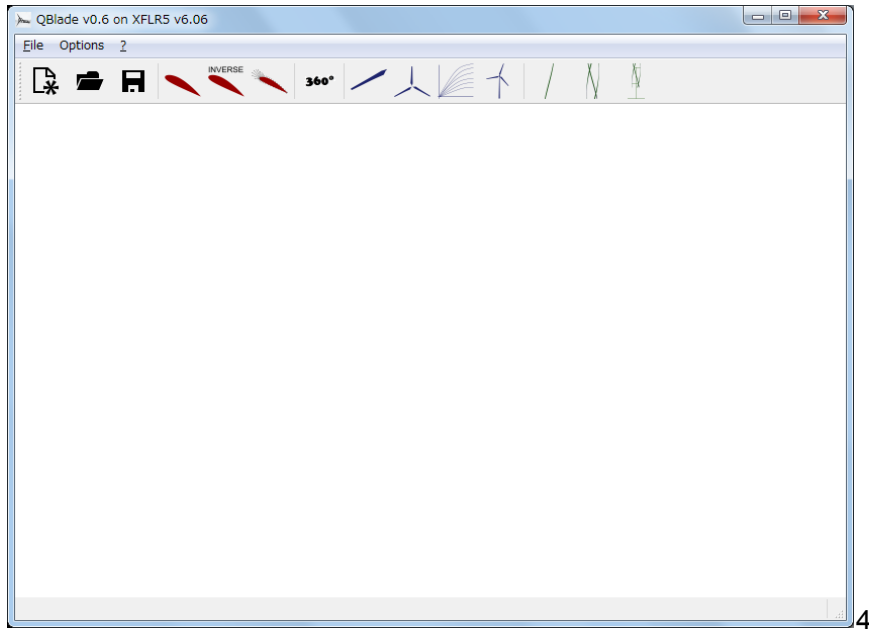


## 5. Analyze

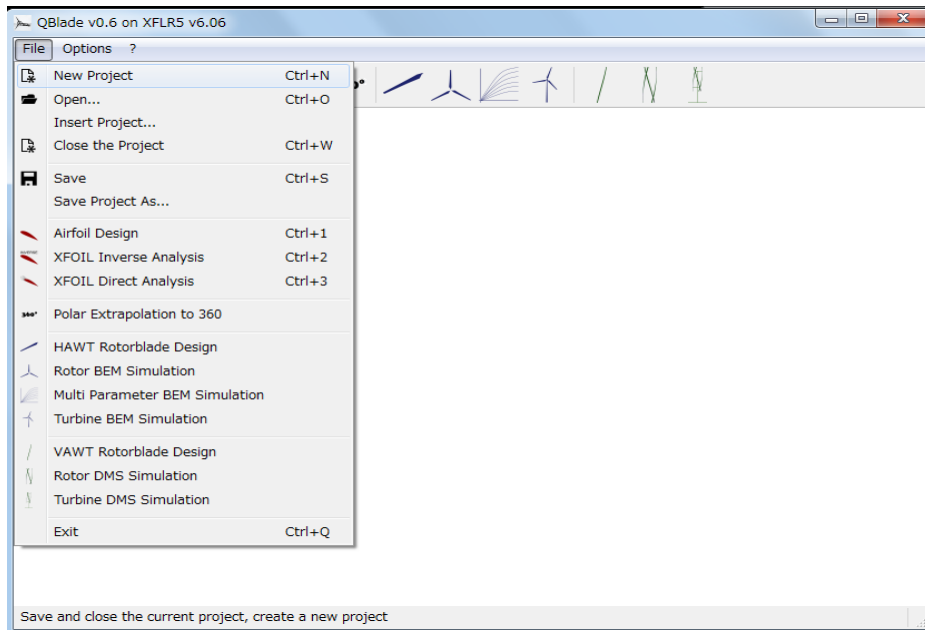
(1) Activate Q Blade.



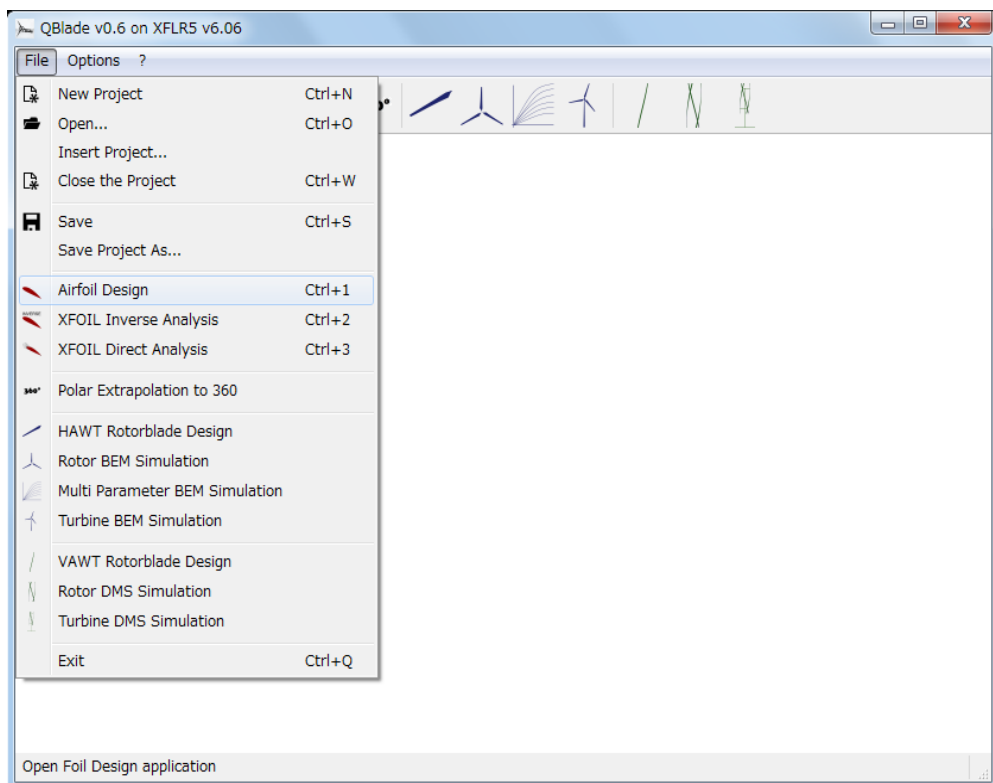
**Double Click**

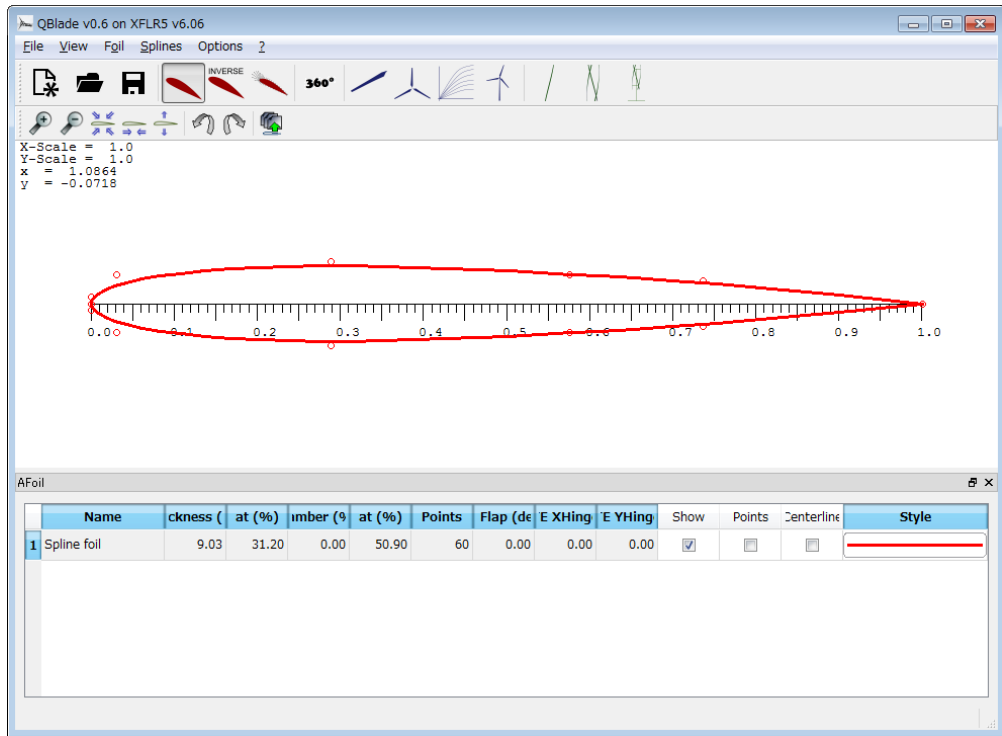


(2) Click File → New Project.

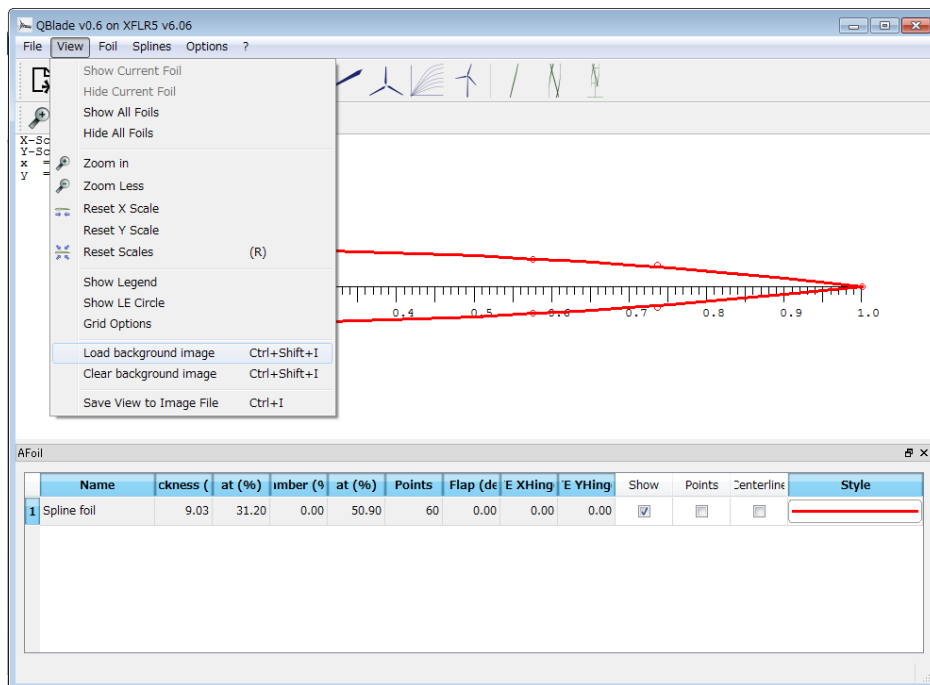


(3) Click File → Airfoil Design.

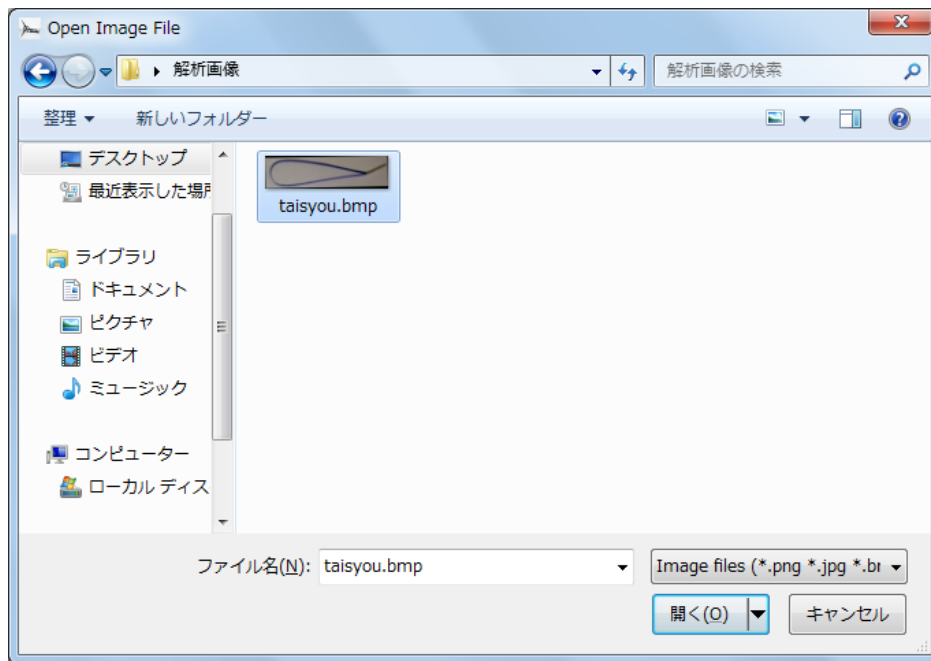




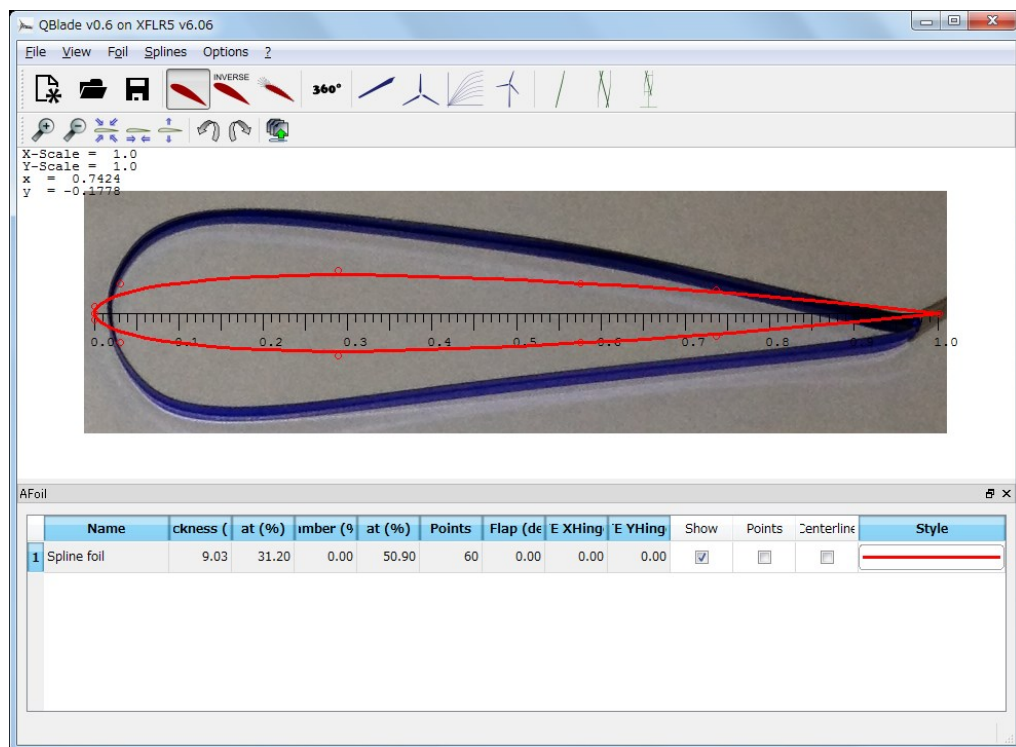
(4) Click View → Load background Image.



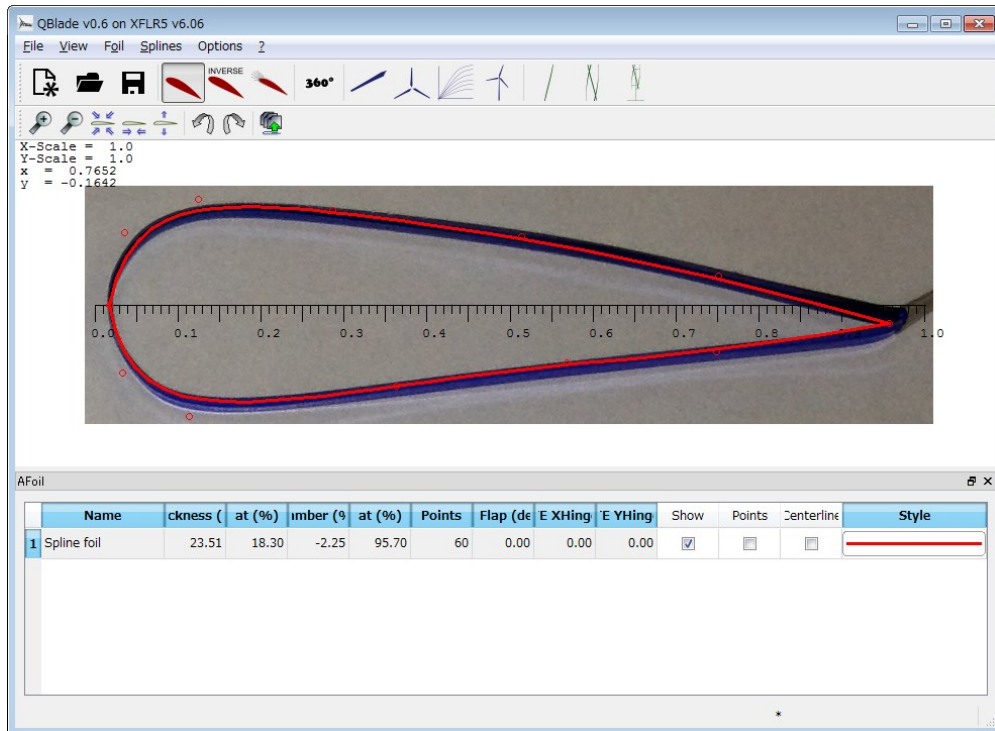
(5) Choose the image saved in I -4-(5).



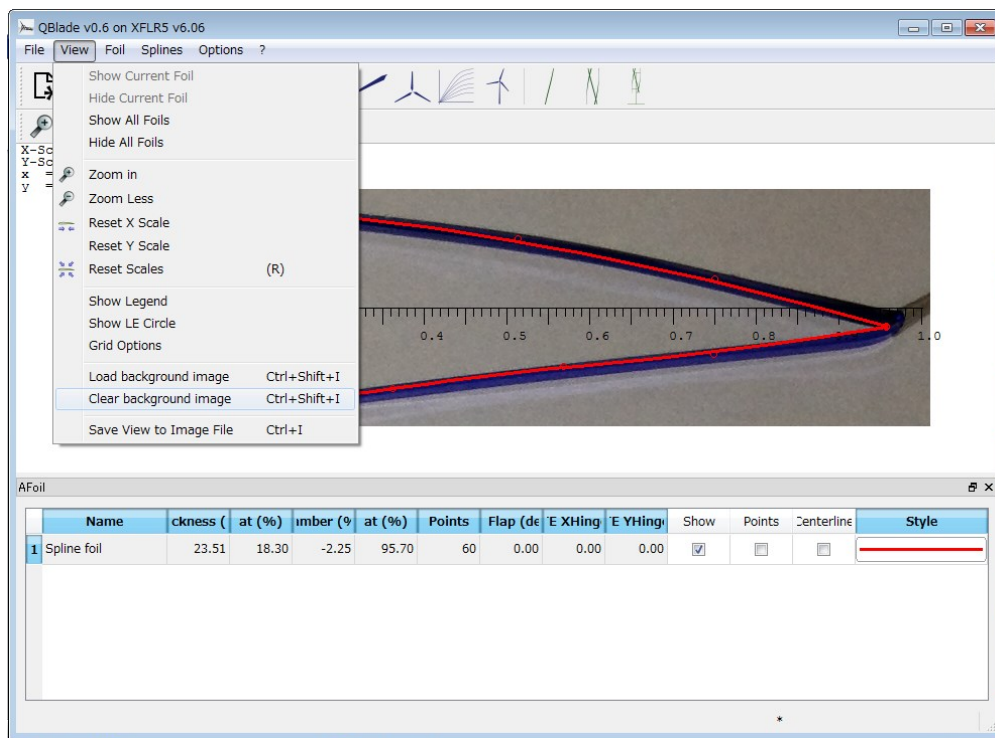
(6) The image chosen in (5) will be shown in the background.



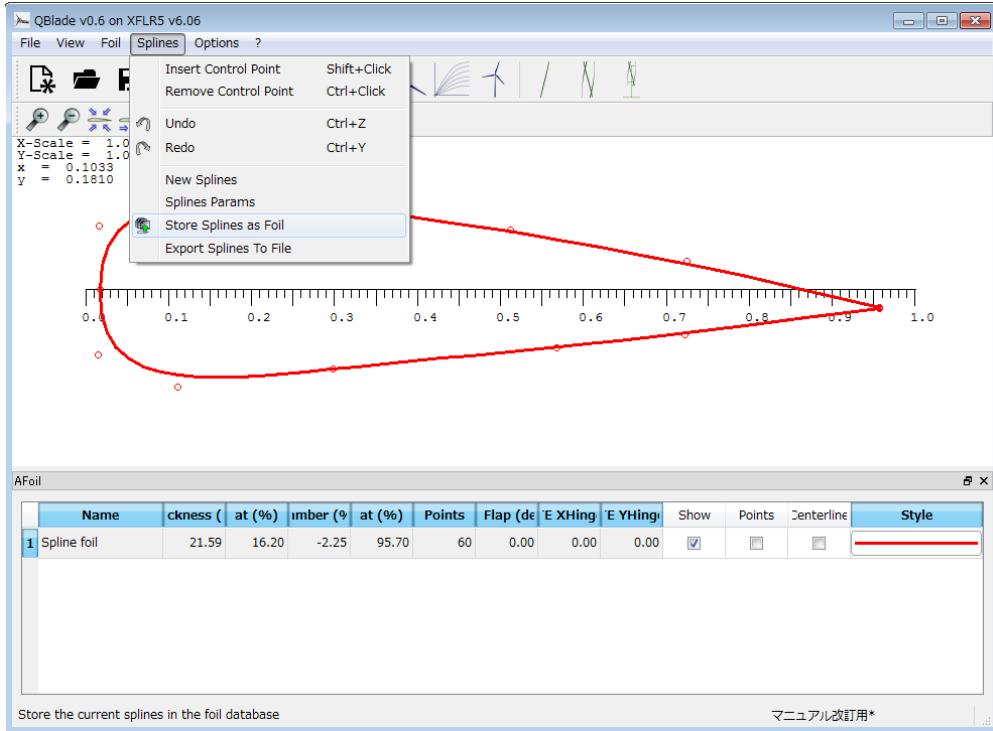
(7) Drag the red line along the background image.



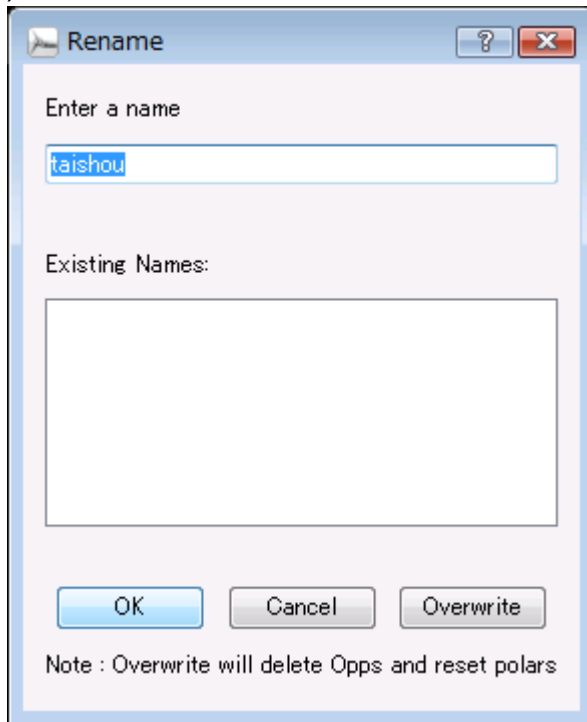
(8) Click View → Clear background Image.



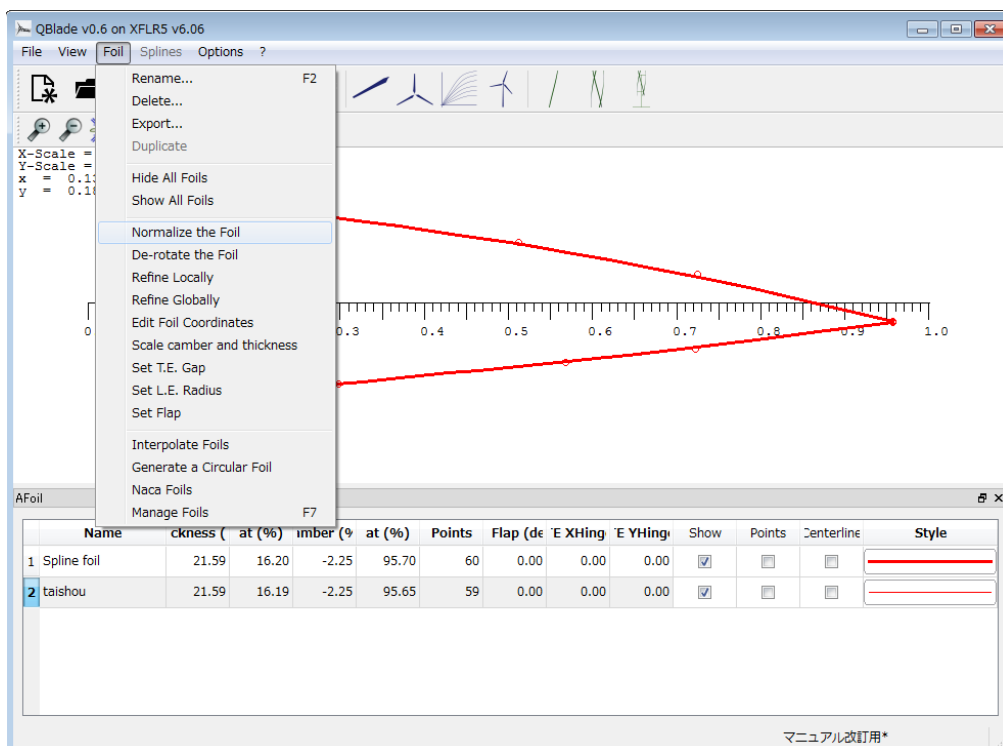
(9) Click Splines → Store Splines as Foil.



(10) Enter the name and click OK.

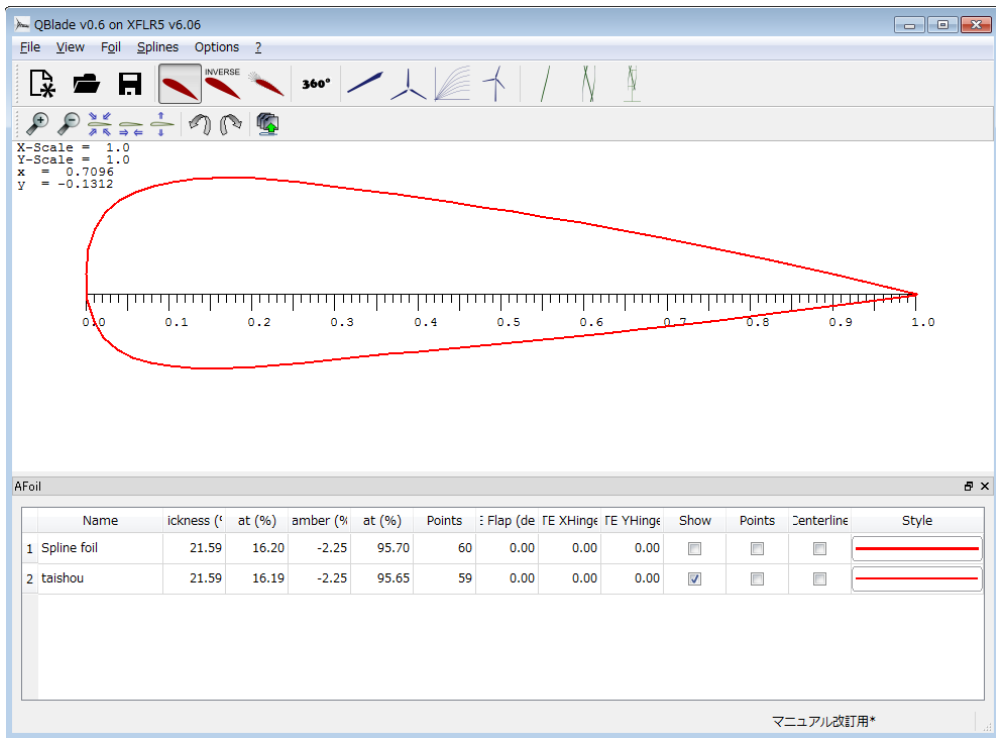


(11) Click Foil → Normalize the Foil. (make the standard coordinate system between 0~1.0)

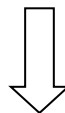
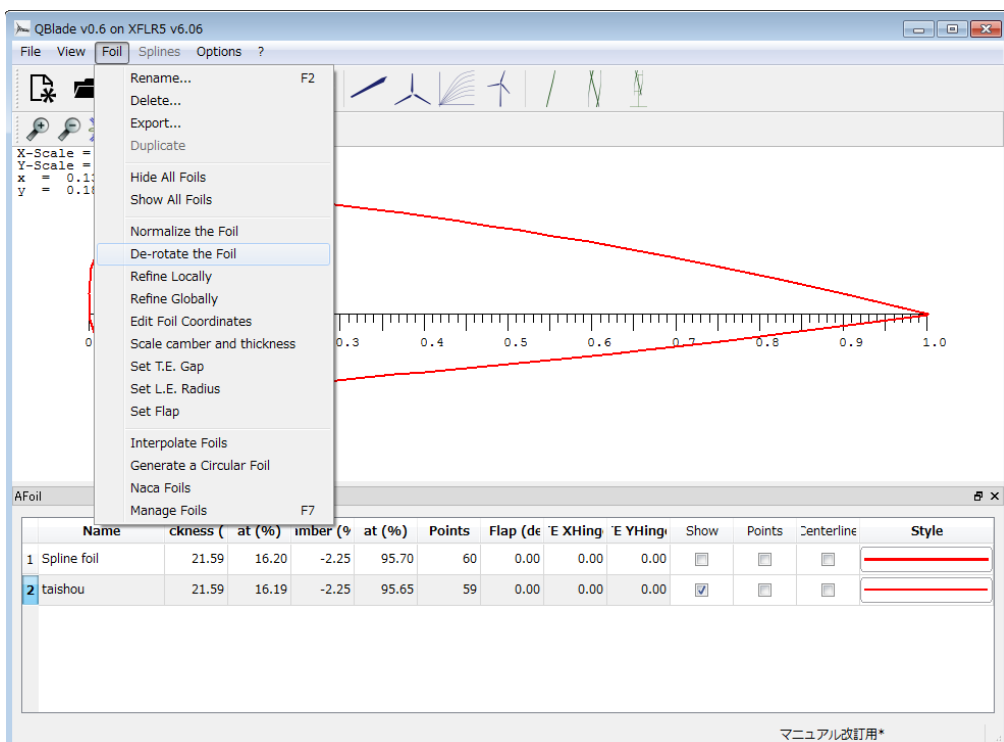


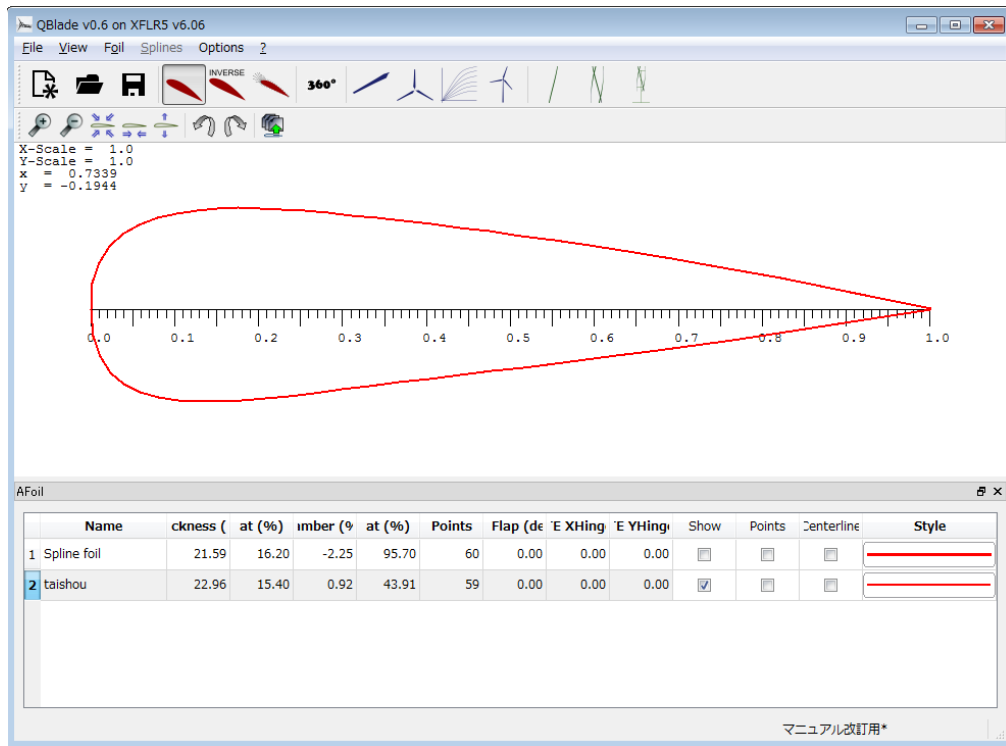
↓  
24



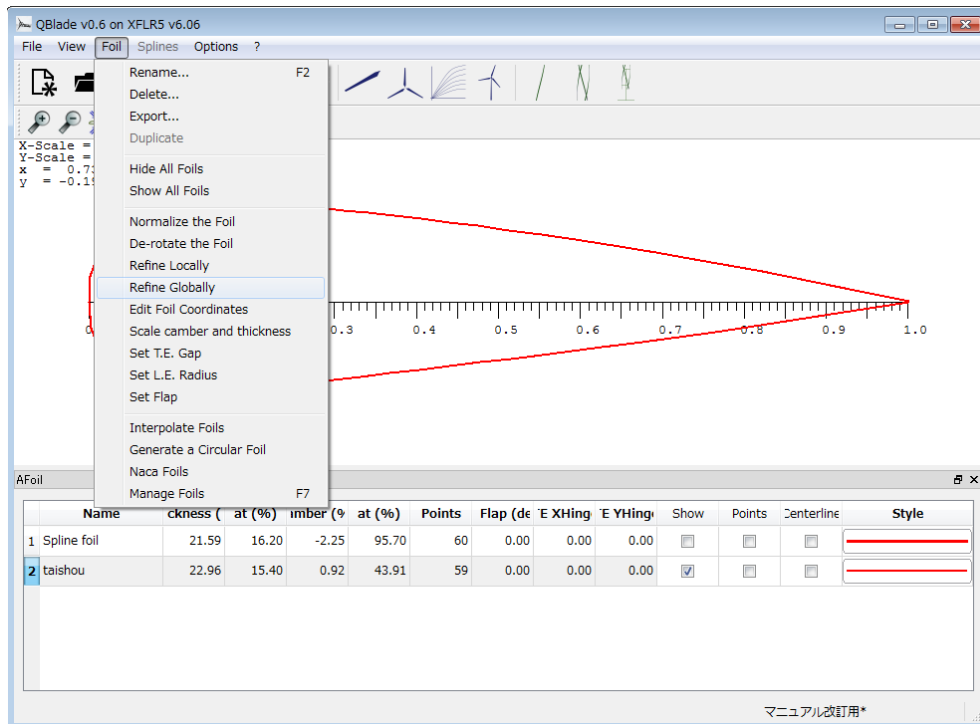


(12) Choose Foil → De-Rotate the Foil and click Overwrite  
(Rotate the blade form and correcting the position)

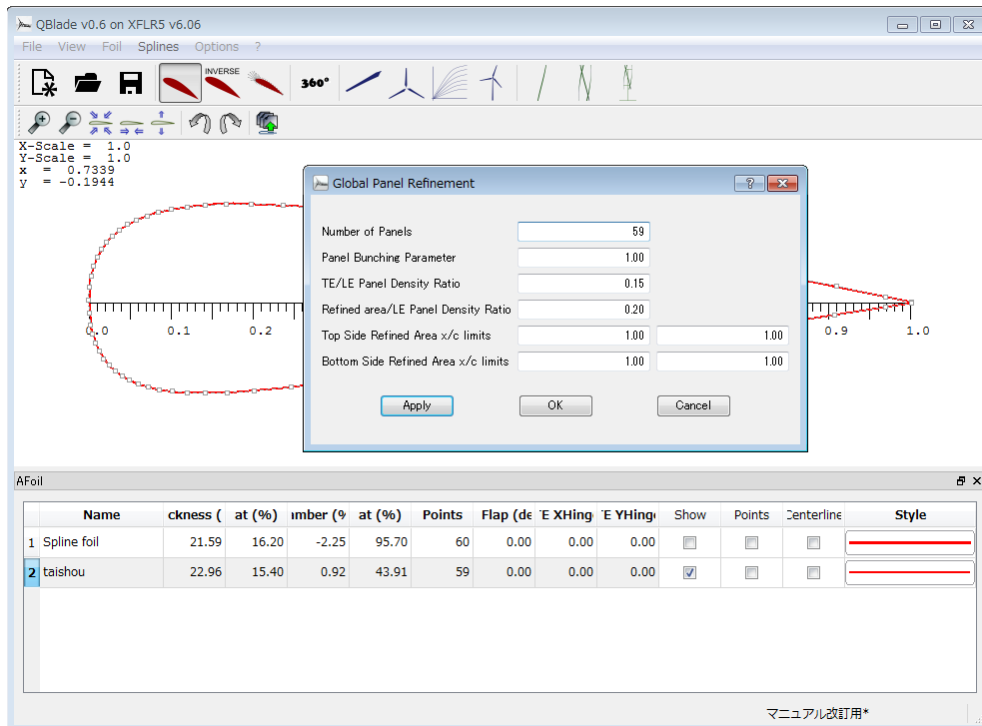




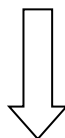
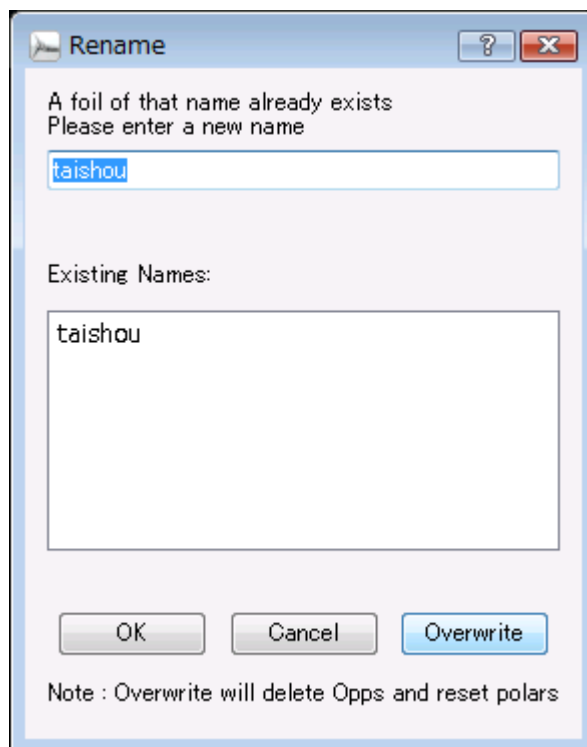
(13) Click Foil → Refine Globally. (Smoothing the coordinates)

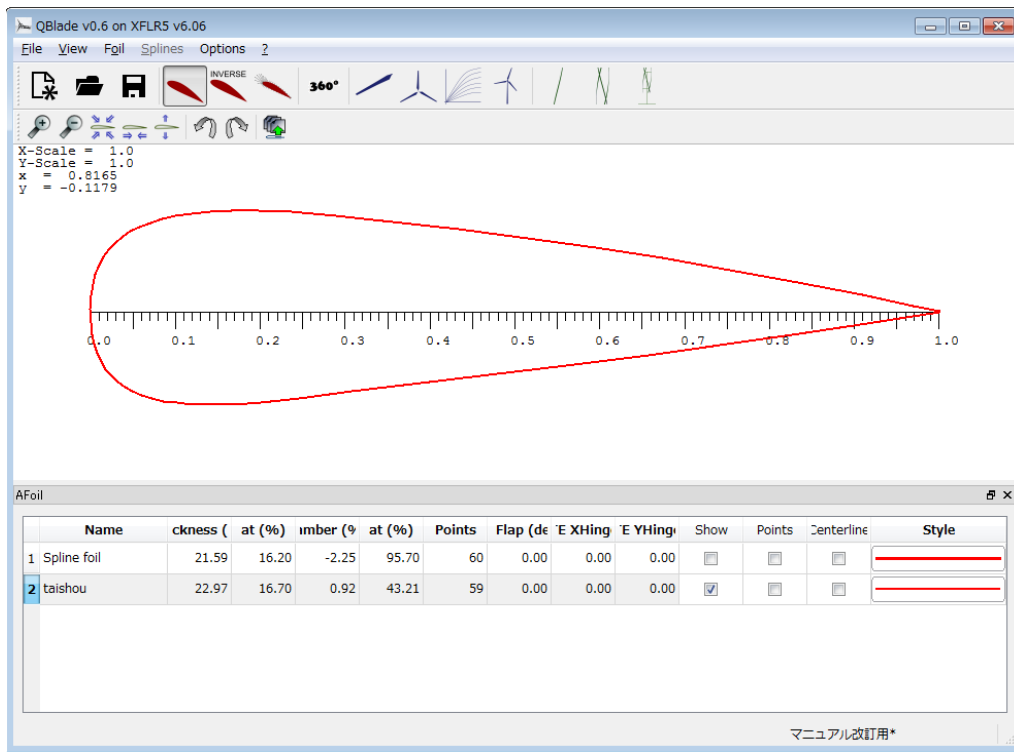


(14) Choose Apply and click OK.

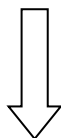
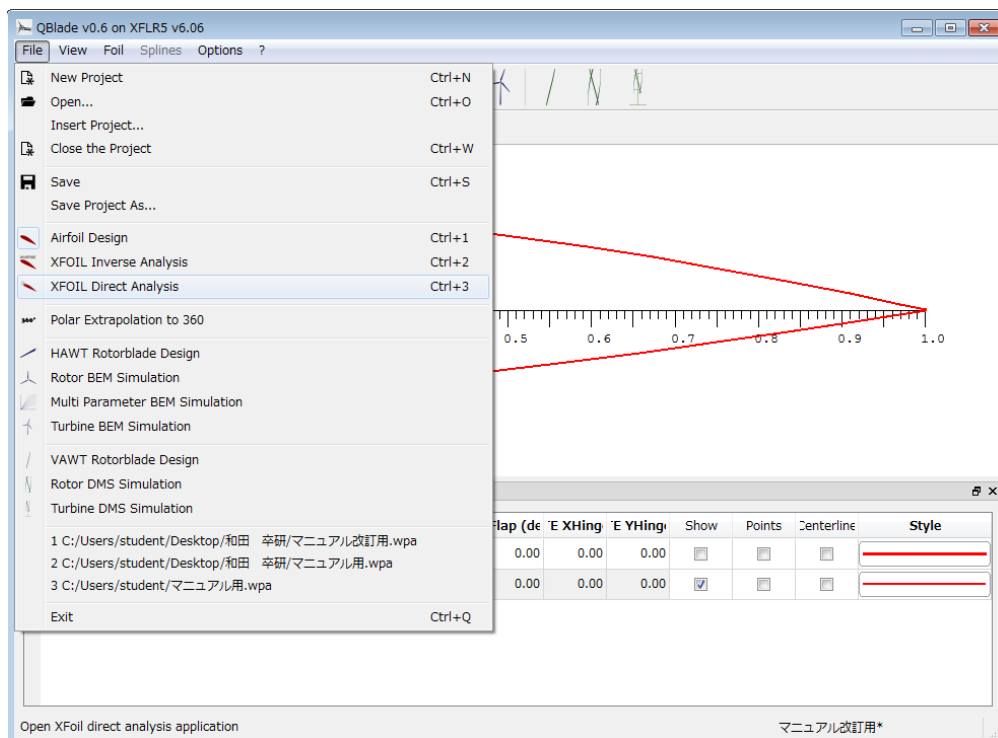


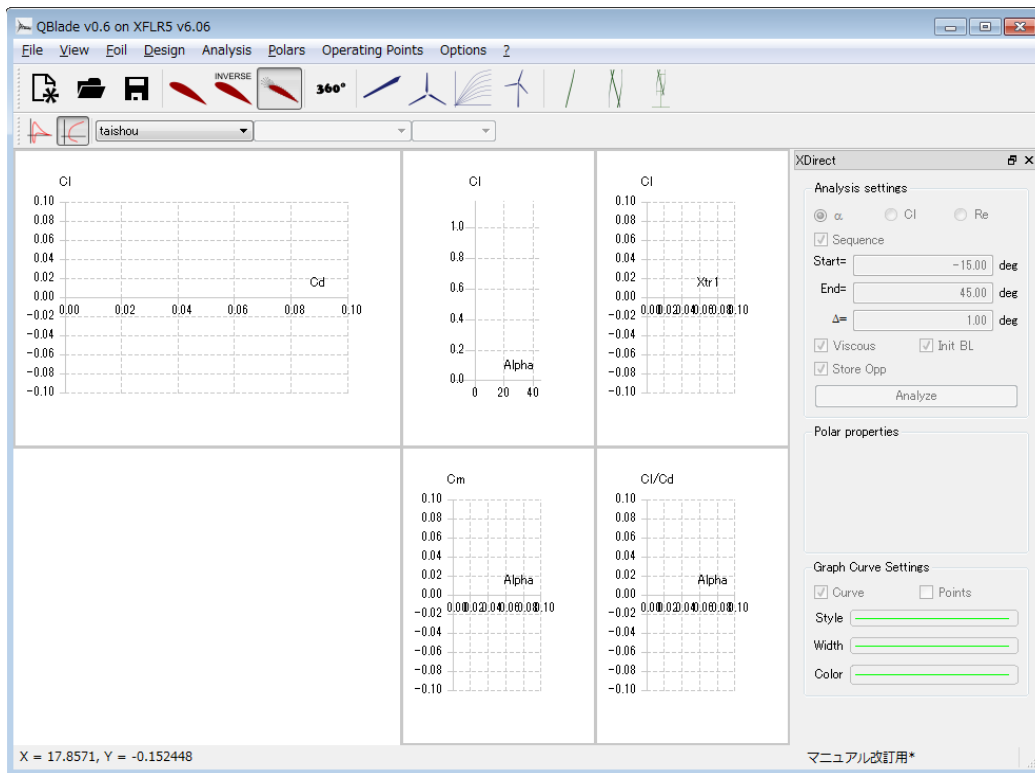
(15) Choose Overwrite.



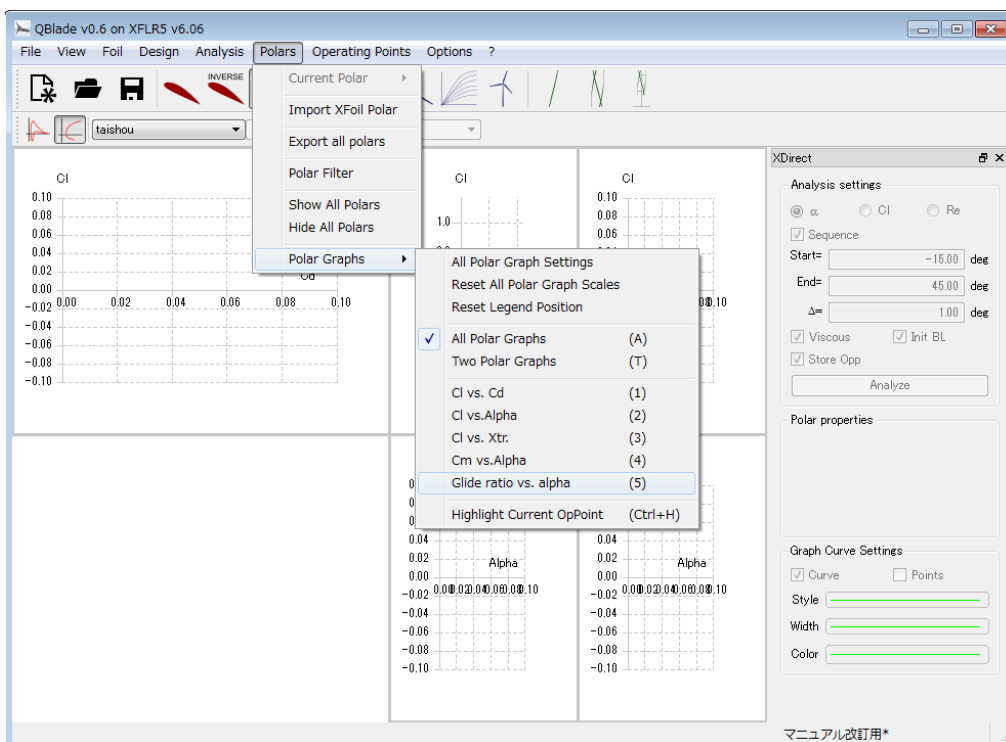


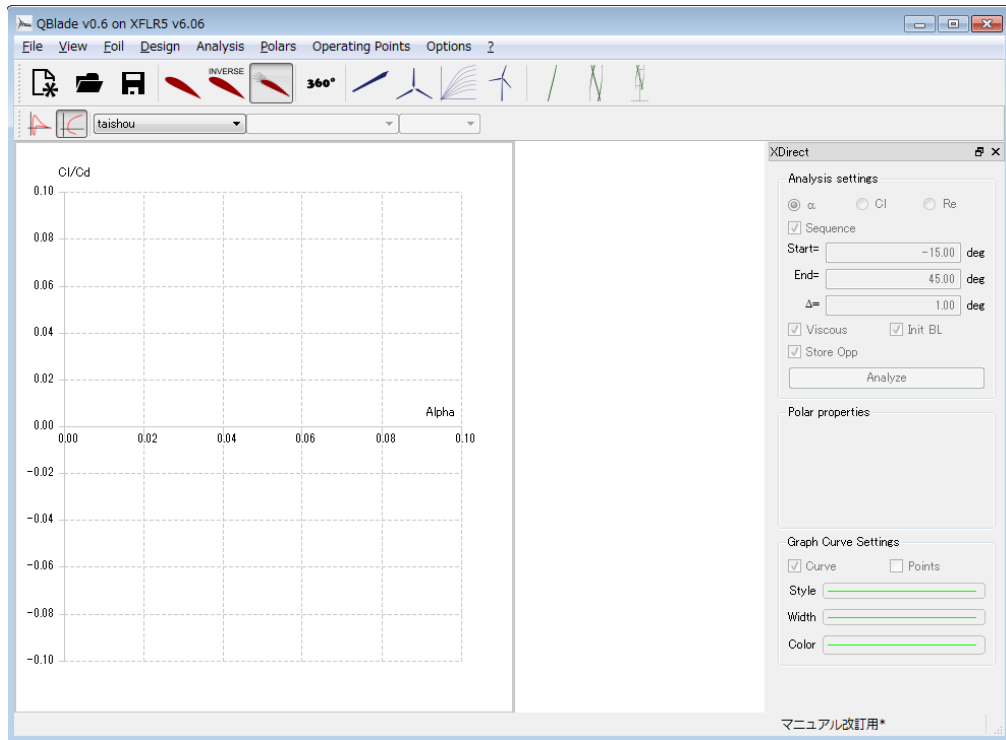
(16) Click File → X Foil Direct Analysis.



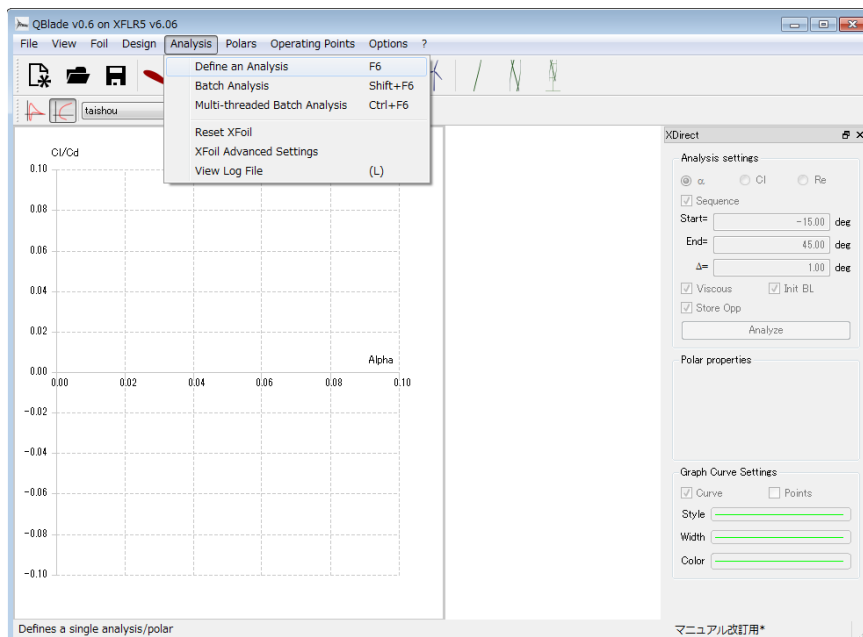


(17) Click Polar → Polar Graphs → Glide ratio vs. alpha.





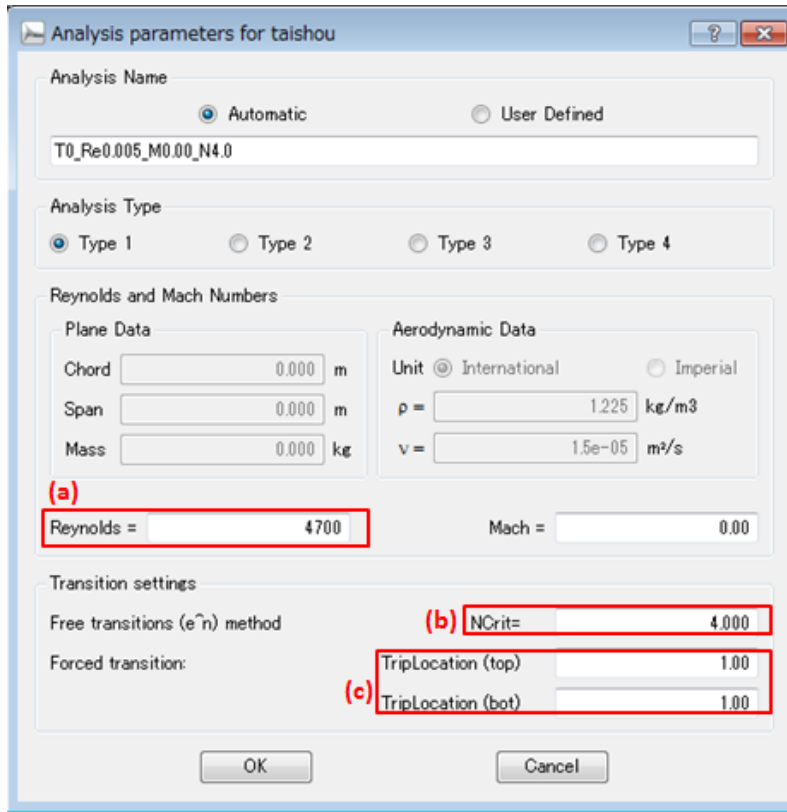
(18) Click Analysis → Define an Analysis.



(19) Enter the analysis condition and click OK.

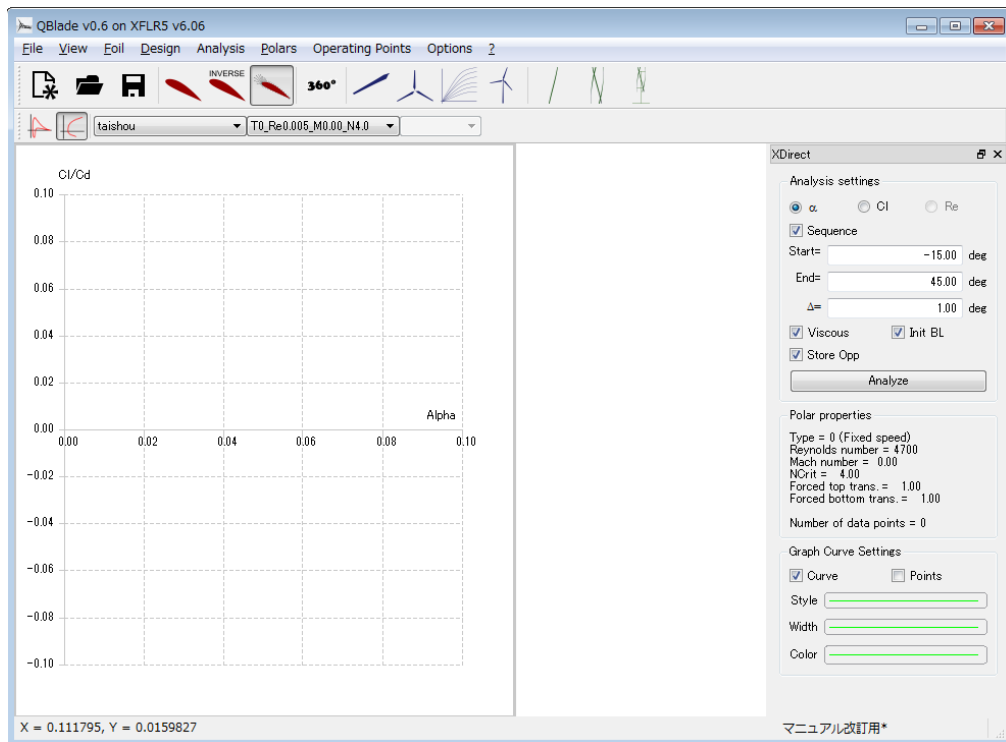
- (a) Enter the Reynolds number calculated in **I -1-(d)**.
- (b) Enter the transition's coefficient if needed. (ex. 9 →4)

(c) Enter the transition position if needed.

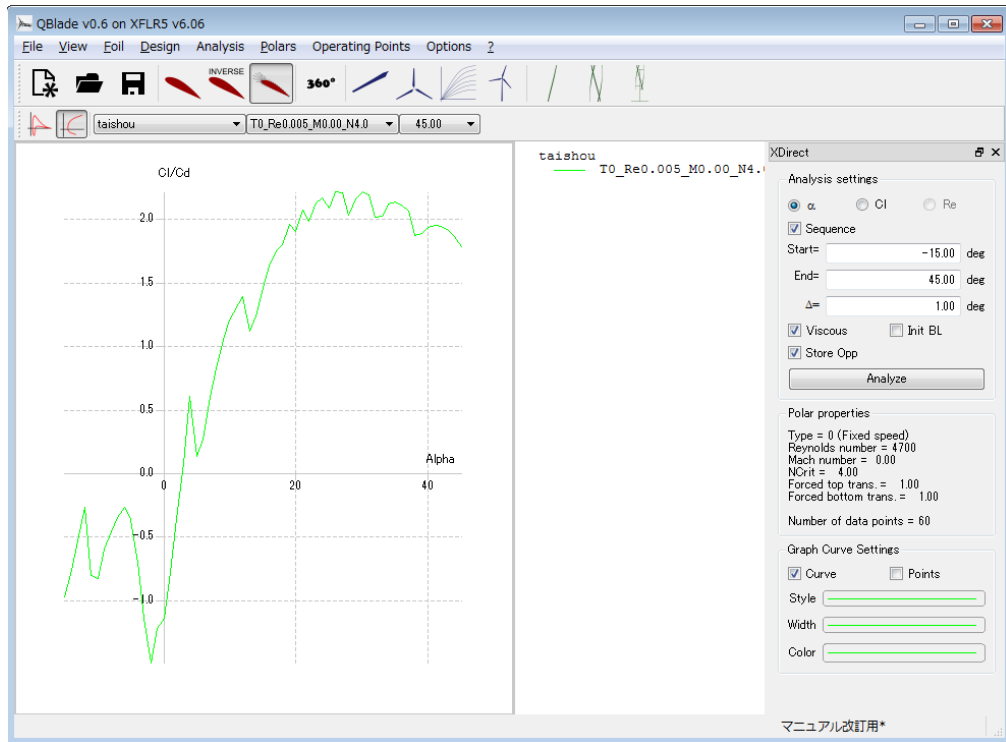


(20) Click Analyze and start analyzing.

- Change the angle of  $\alpha$  ( $0^\circ \sim 45^\circ \rightarrow -15^\circ \sim 45^\circ$ )



(20) Result shown below.

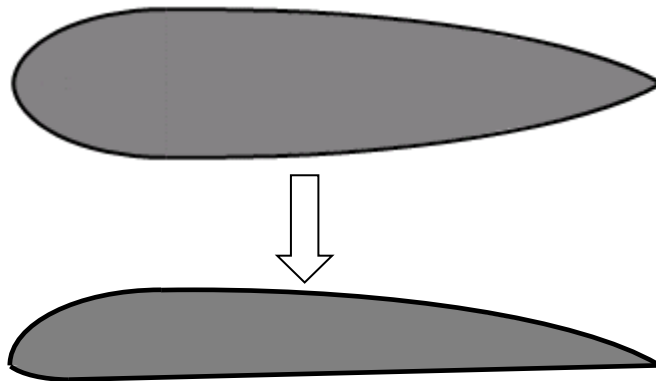


## II Analysis of the blade form

### 1. Obtaining data samples

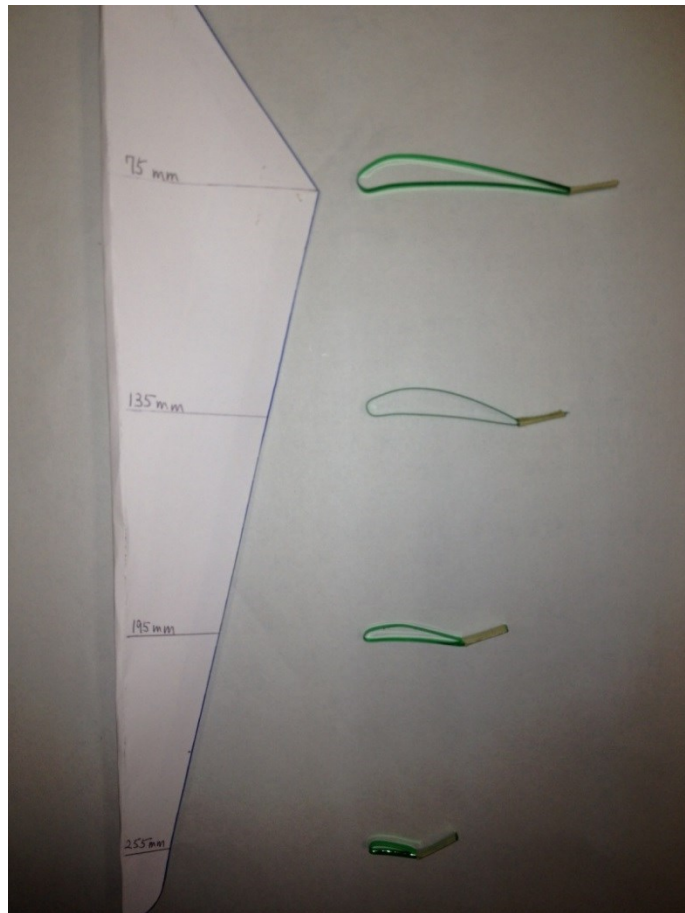
#### (1) Preparation

- Change the blade form of the paper craft wind turbine.



- Design the blade form using the wire tie and the plastic tape as you did for the symmetrical blade.





- Save the image in the computer using scanners or digital cameras.



(2) Instructions

(a) Measuring the wind speed.

- Use the data from **I -1-(2)** for the wind speed without the fan.
- Measure the wind speed in front side and back side of the fan in every length, air strength and take the average.

		弱		中		強	
		前	後	前	後	前	後
0 . 7	下						
	中						
	上						
1 . 0	下						
	中						
	上						
1 . 2	下						
	中						
	上						

	弱		中		強	
	前	後	前	後	前	後
0.75						
1.00						
1.25						

(b) Calculate the reduction ratio

- Calculate the reduction ratio using the next equation.

$$\text{減速比} = \frac{\text{風車前の風速}}{\text{風車なしの}}$$

	減速比		
	弱	中	強
0.75			
1.00			
1.25			
平均			

(c) Measure the revolution speed

- Measure the revolution speed on every length and wind strength.

	弱	中	強
0.75			
1.00			
1.25			

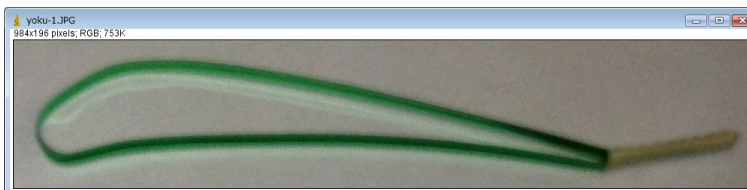
(d) Calculate the Reynolds number

Substitute the result calculated in (a), (b), (c) using the spread sheet software and calculate the Reynolds number.

## 2. Analysis

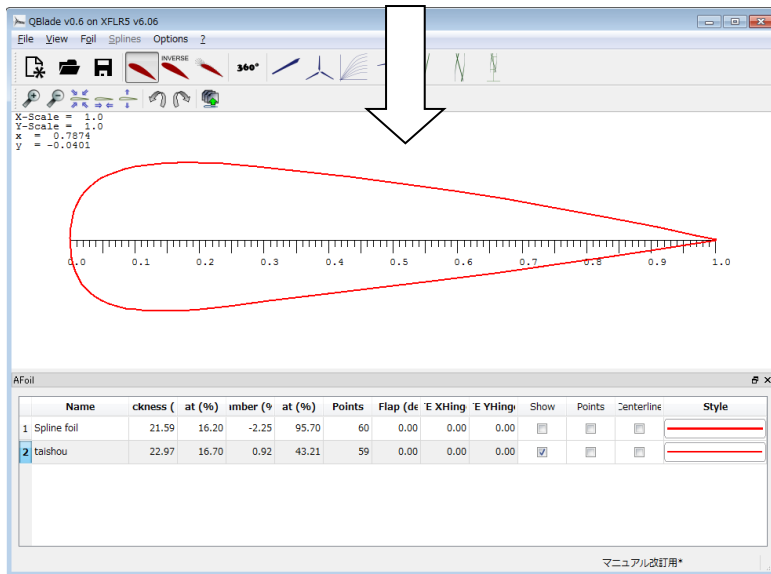
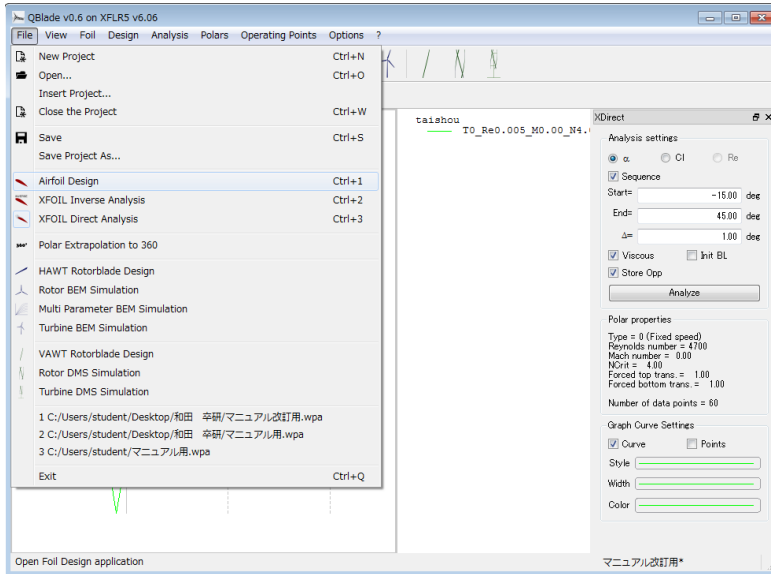
(1) Creating analyzing image

- Create the analyzing image as shown in I -3 and save the image

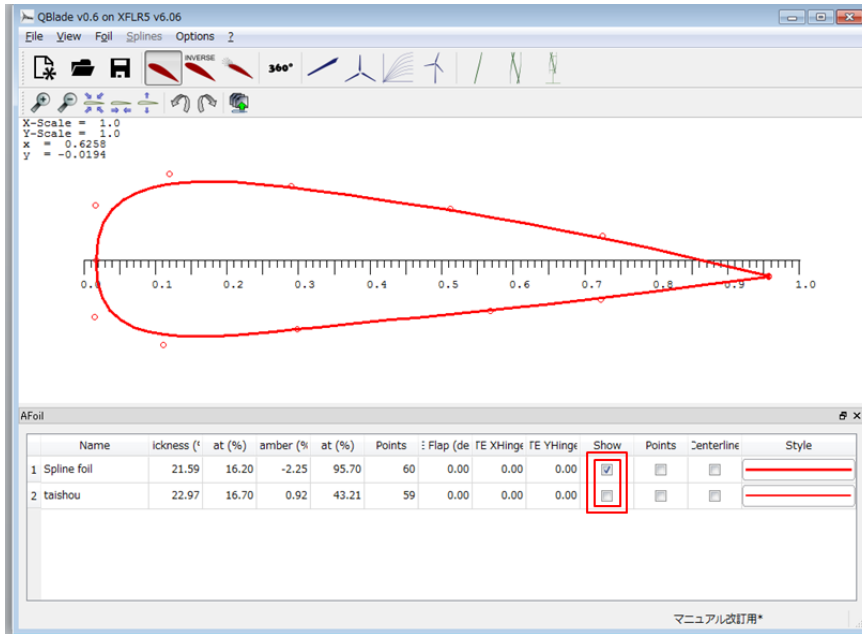


(2) Analyze the image using Q Blade

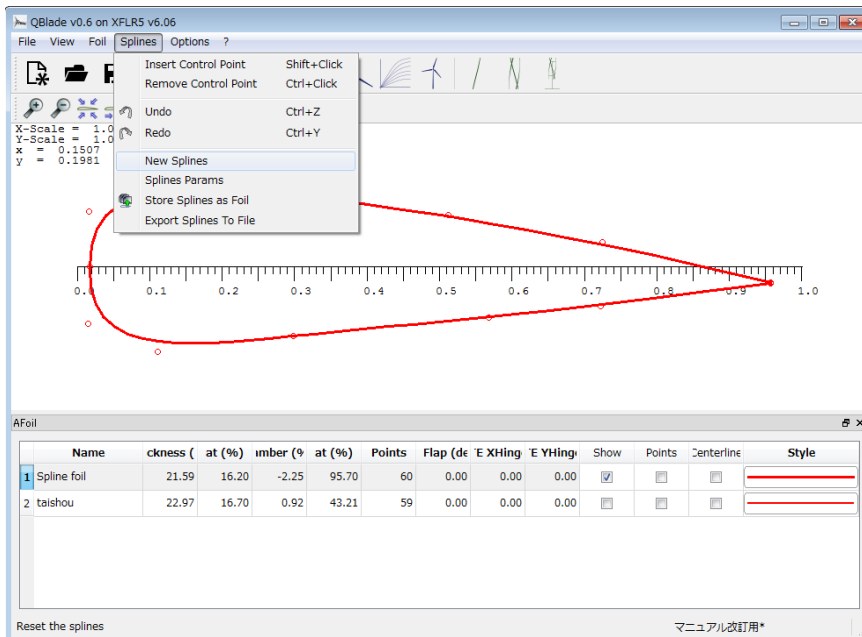
(a) Click File → Airfoil Design.

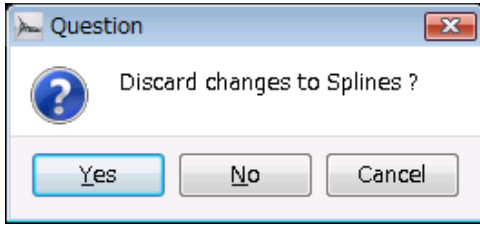


(b) Remove the check from "taishou" and check Spline foil.

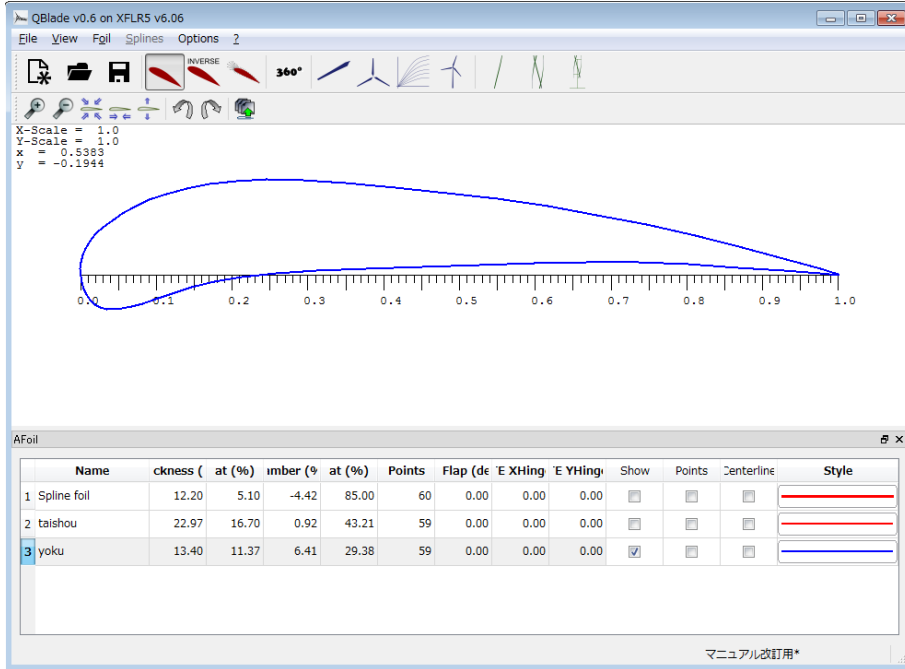


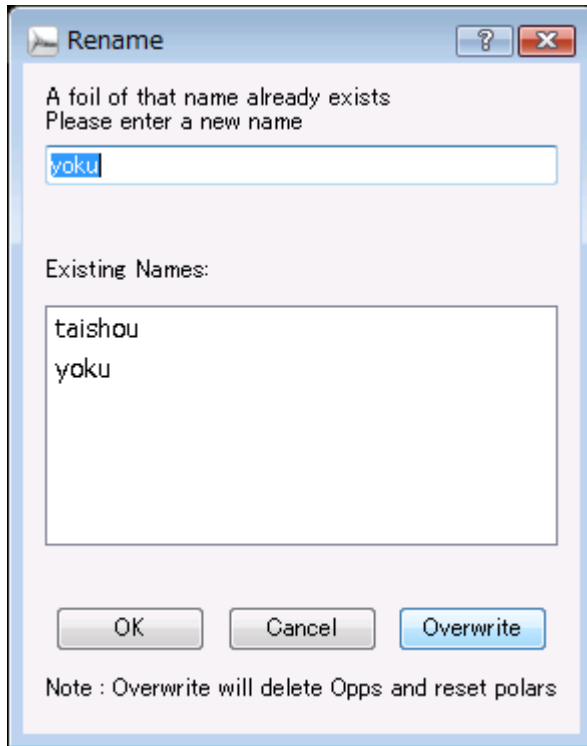
(c)Click Splines → New Splines and click Yes.



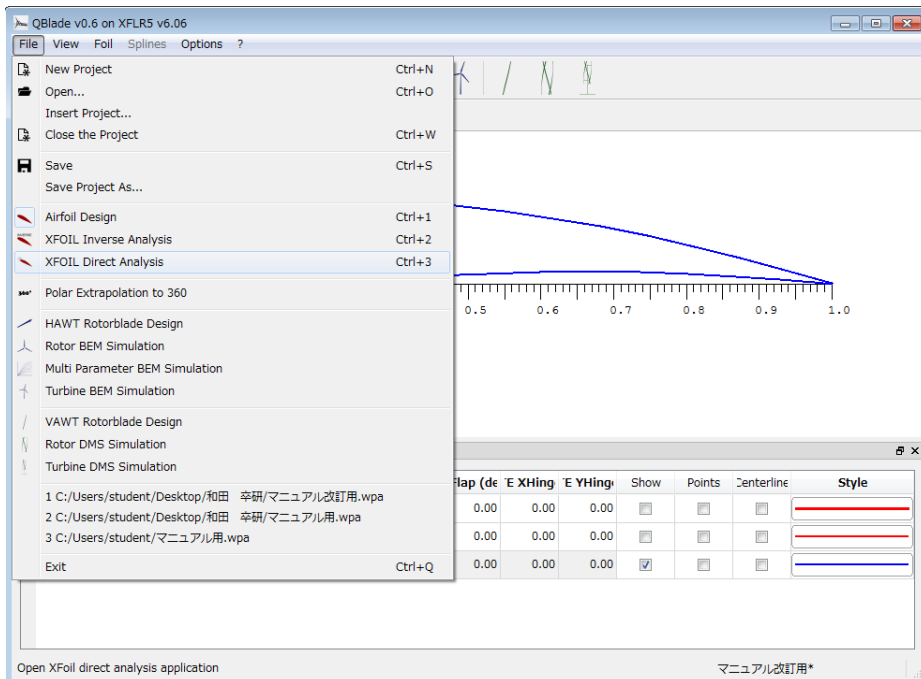


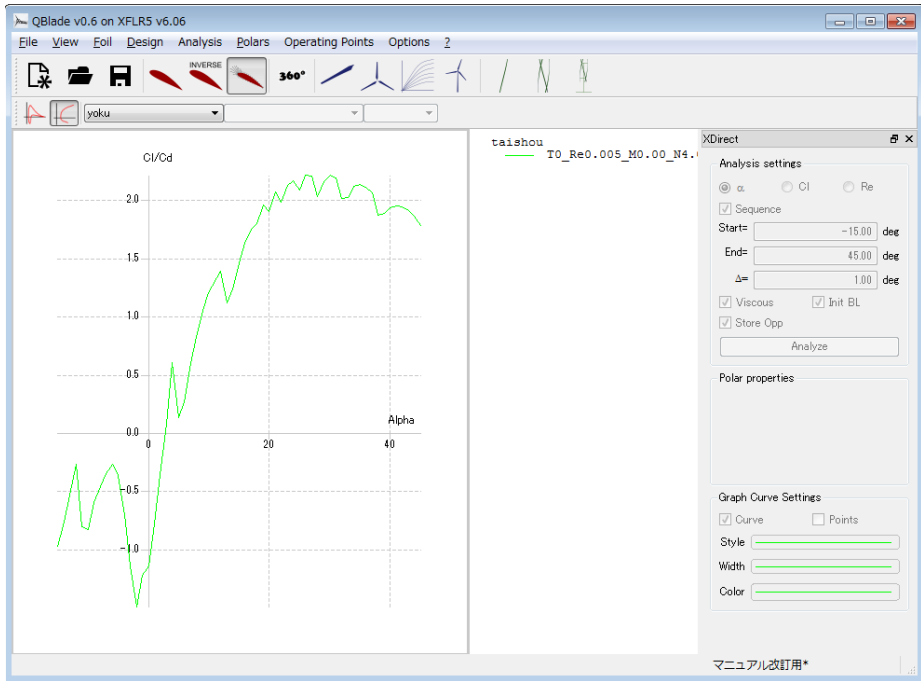
(d) Do the same procedure following I -4-(4)~(15)



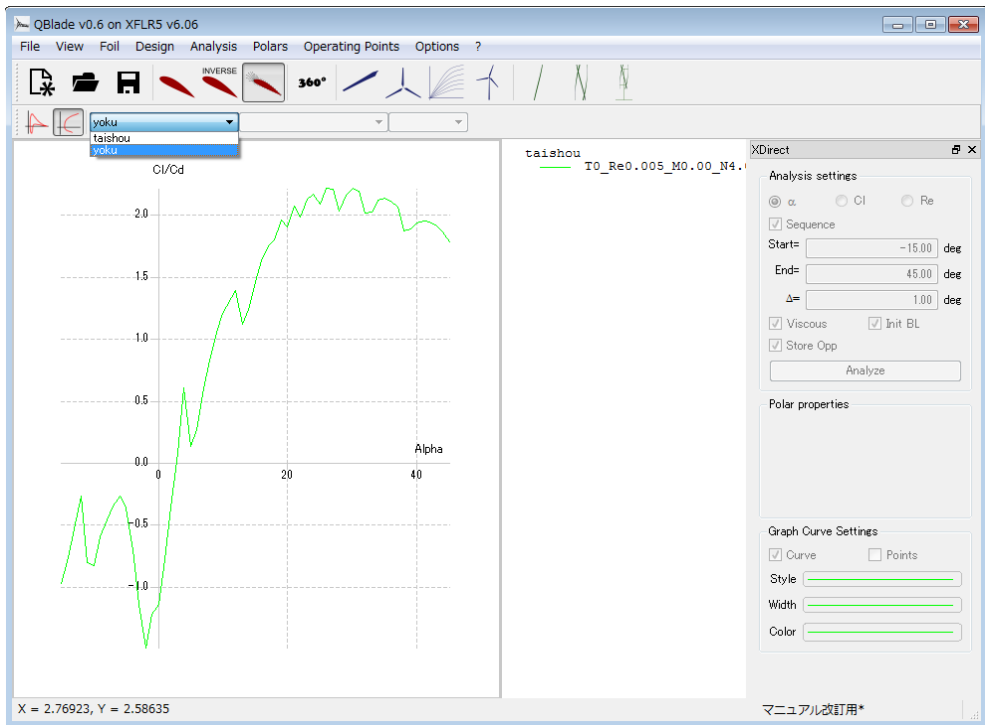


(e)Click File → X foil Direct Analysis.





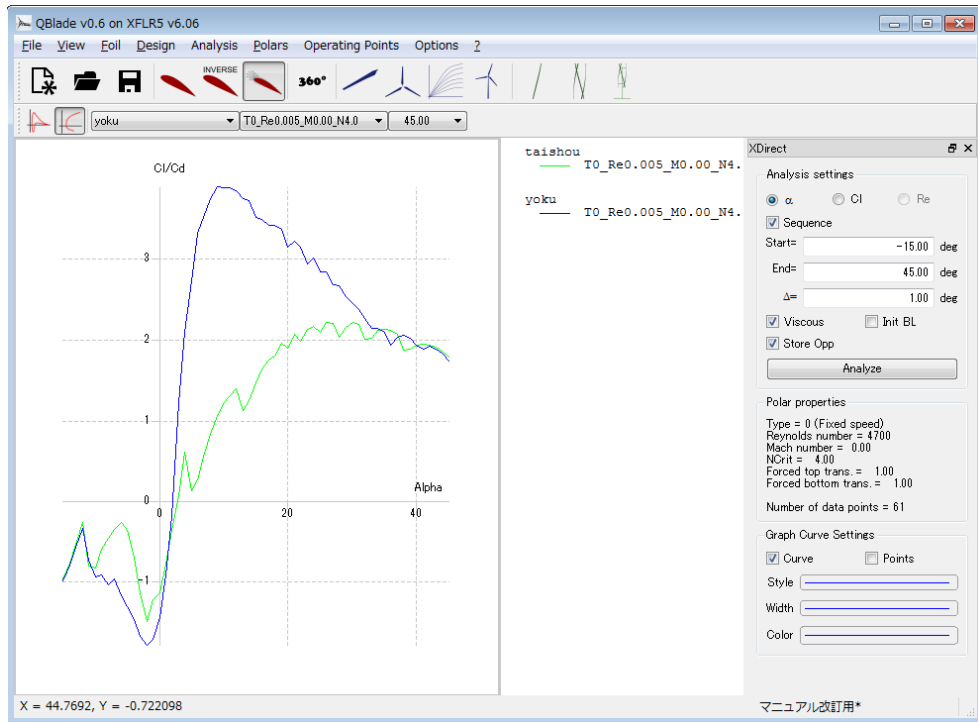
(f)Change from “taishou” to “yoku”.





(g) Analyze following the procedure through I -5-(18)~(20).

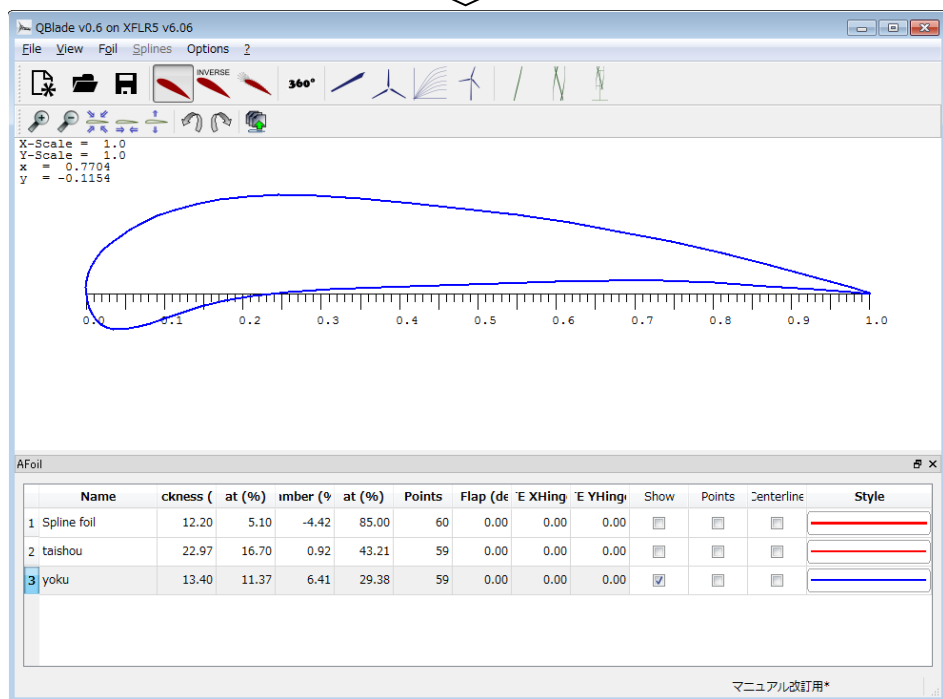
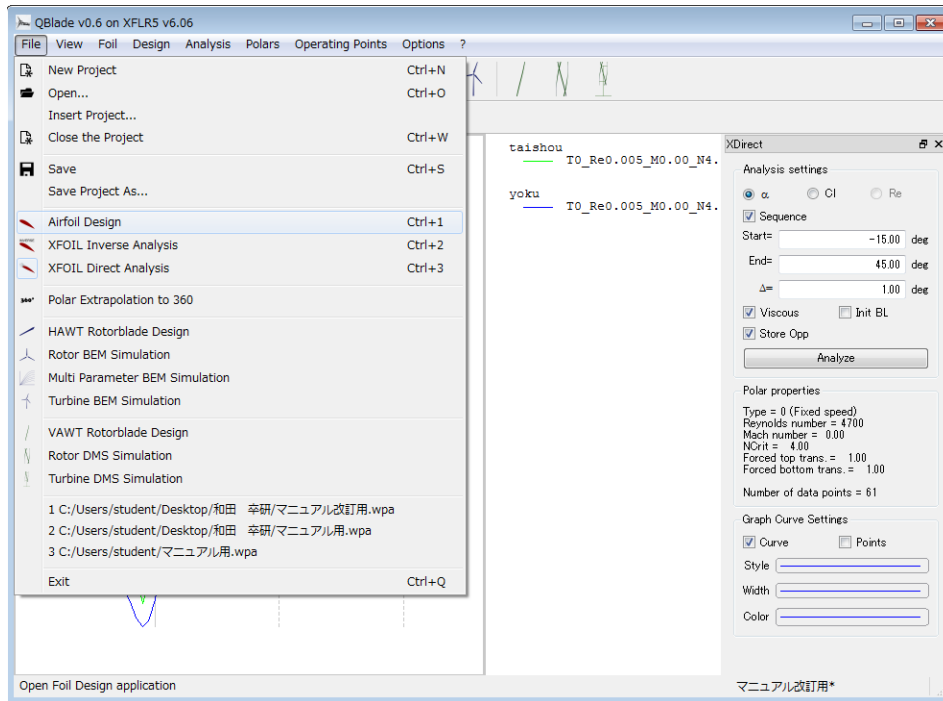
- Type in the Reynold's number calculated in II -1-(d)



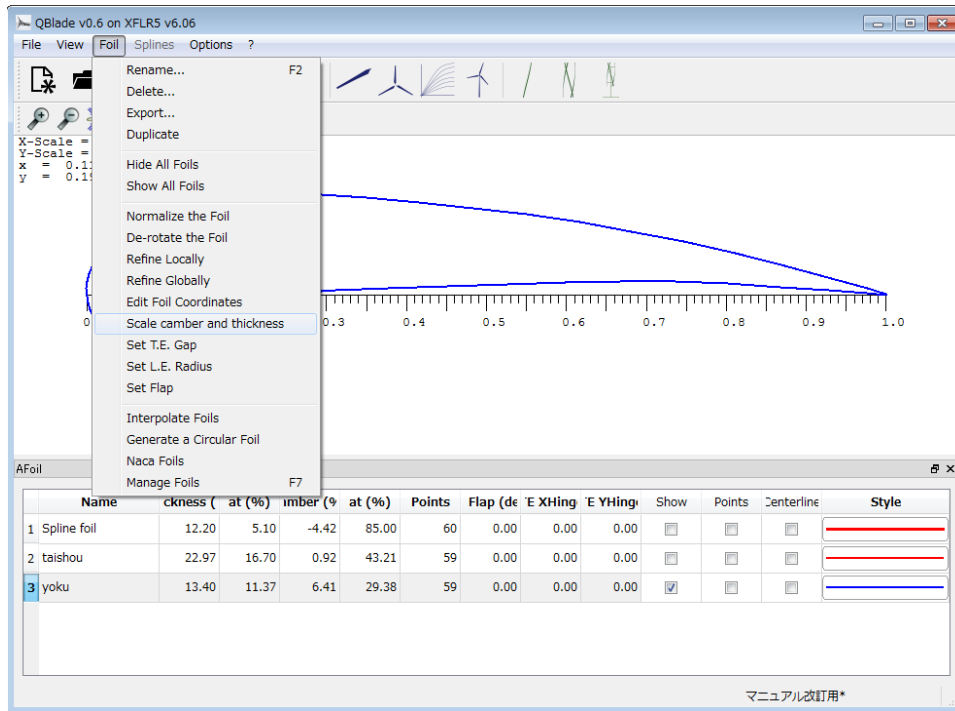
### III Considering the best wing form

## 1. Analyze

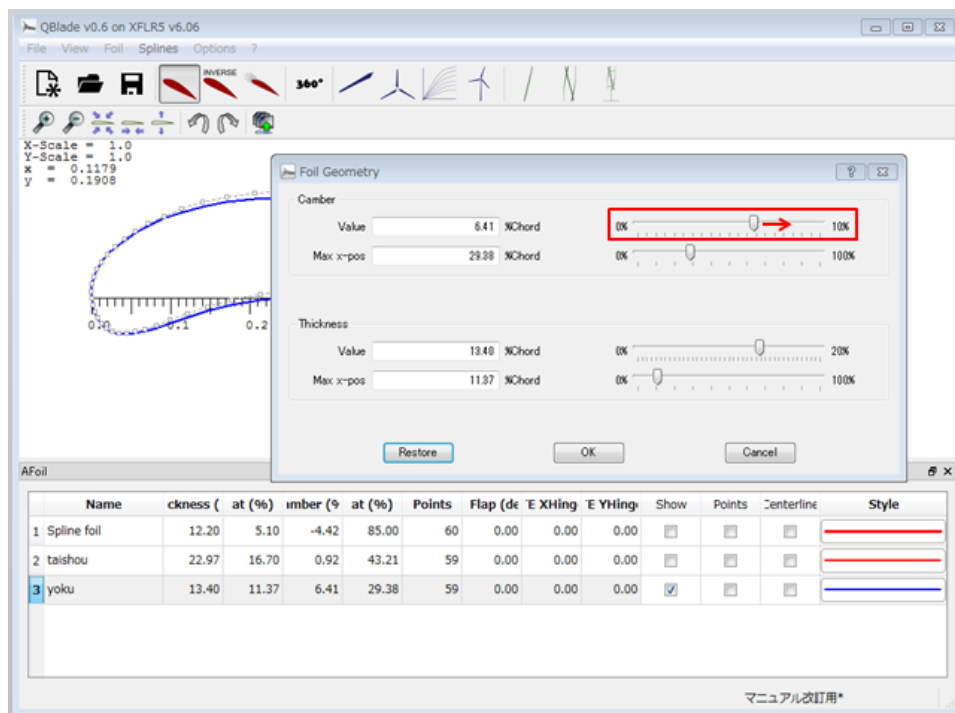
(1) Click File → Airfoil Design.



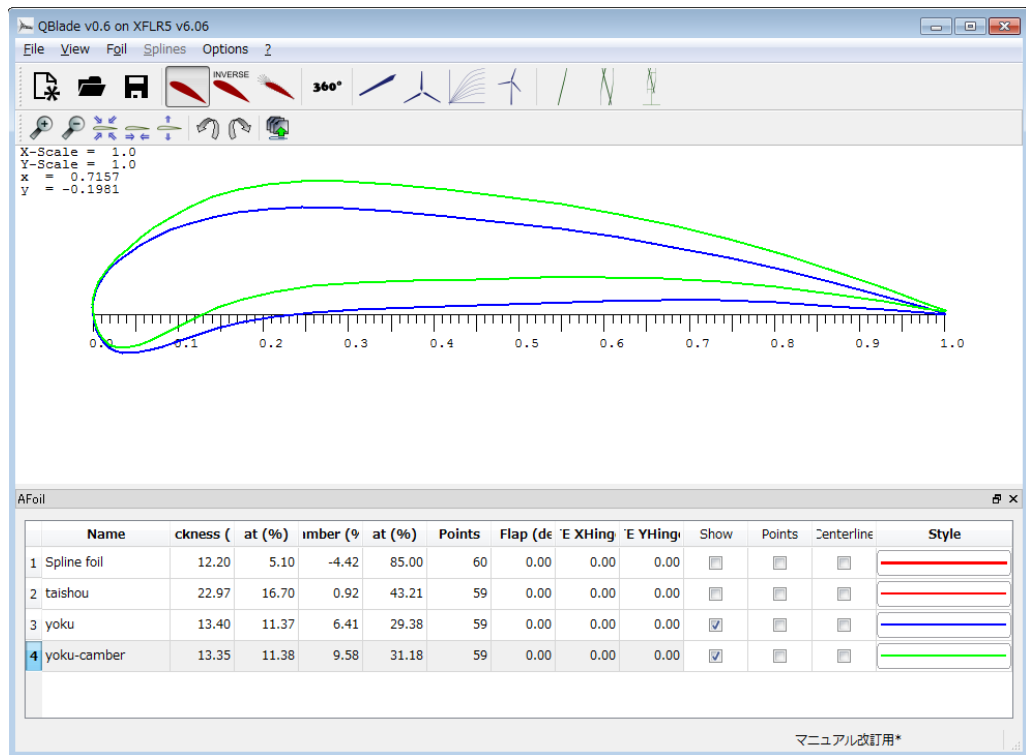
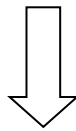
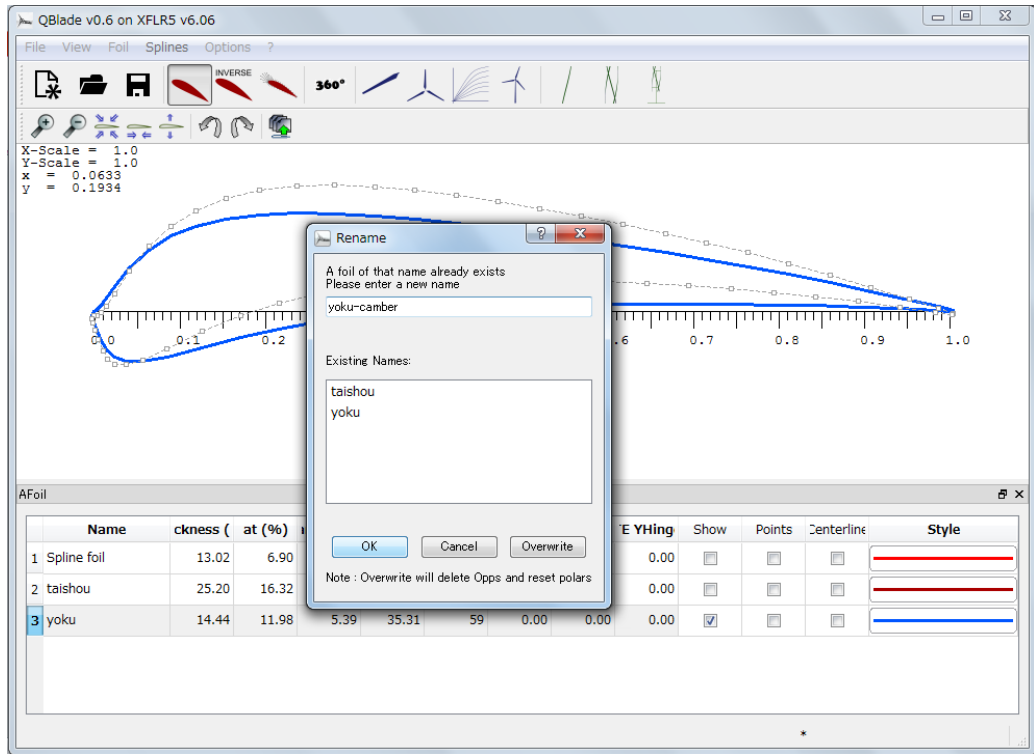
(2) Click Foil → Scale camber and thickness



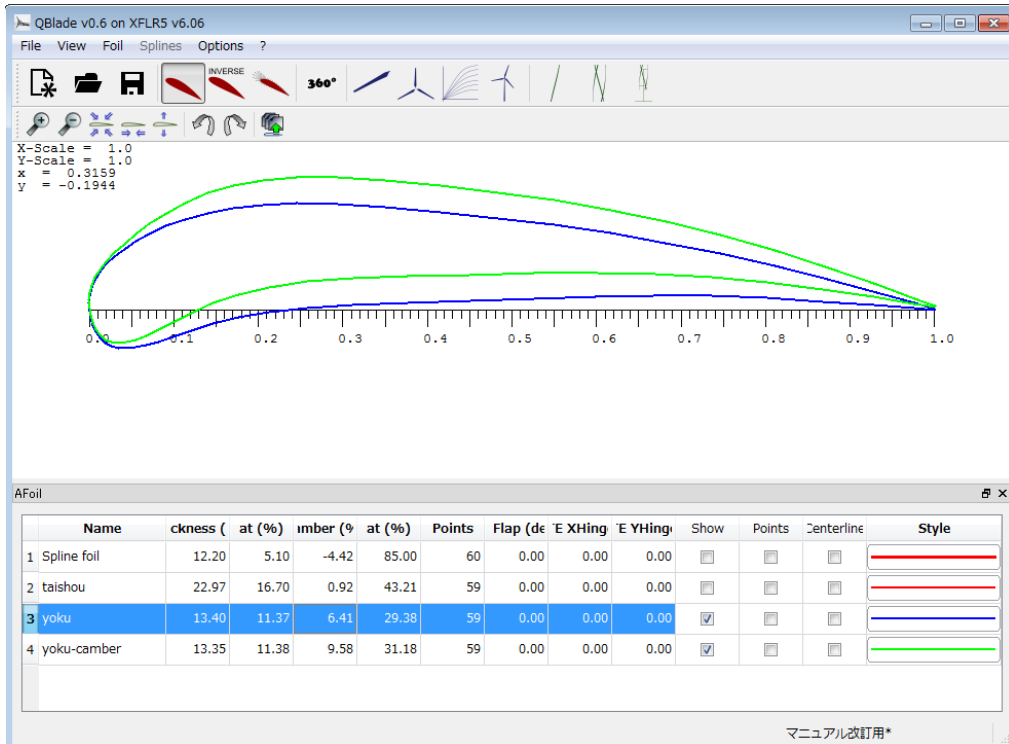
(3) Change the Camber gage and click ok.



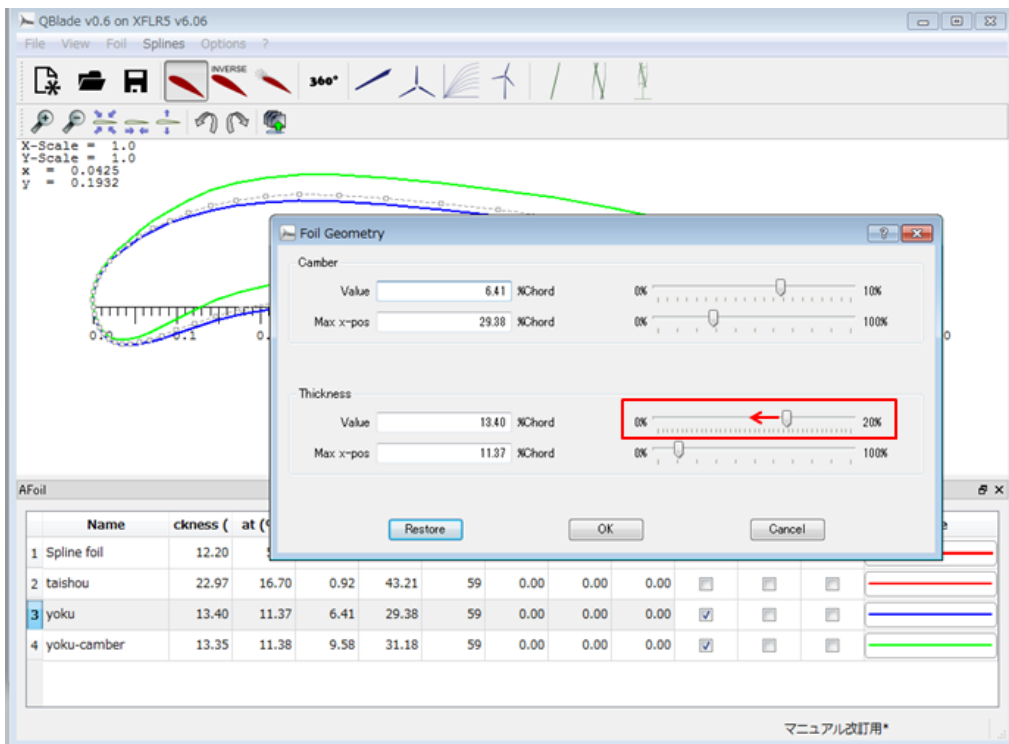
(4) Name the blade and save. (ex. yoku-chamber)



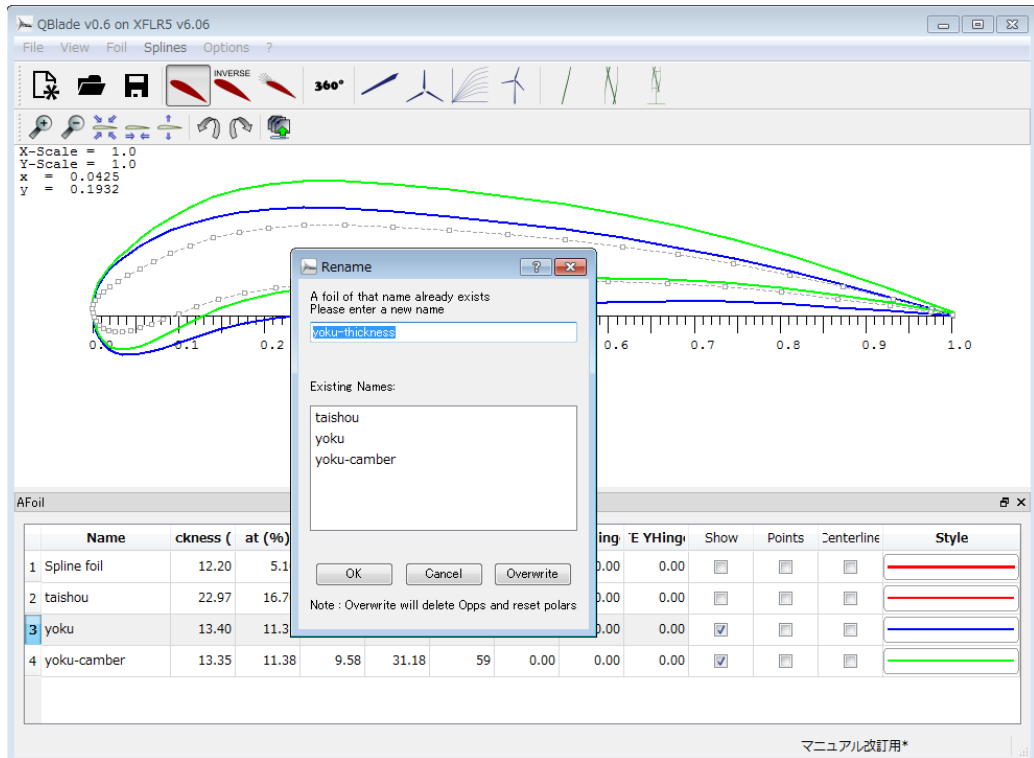
(5) Select the third blade(yoku).



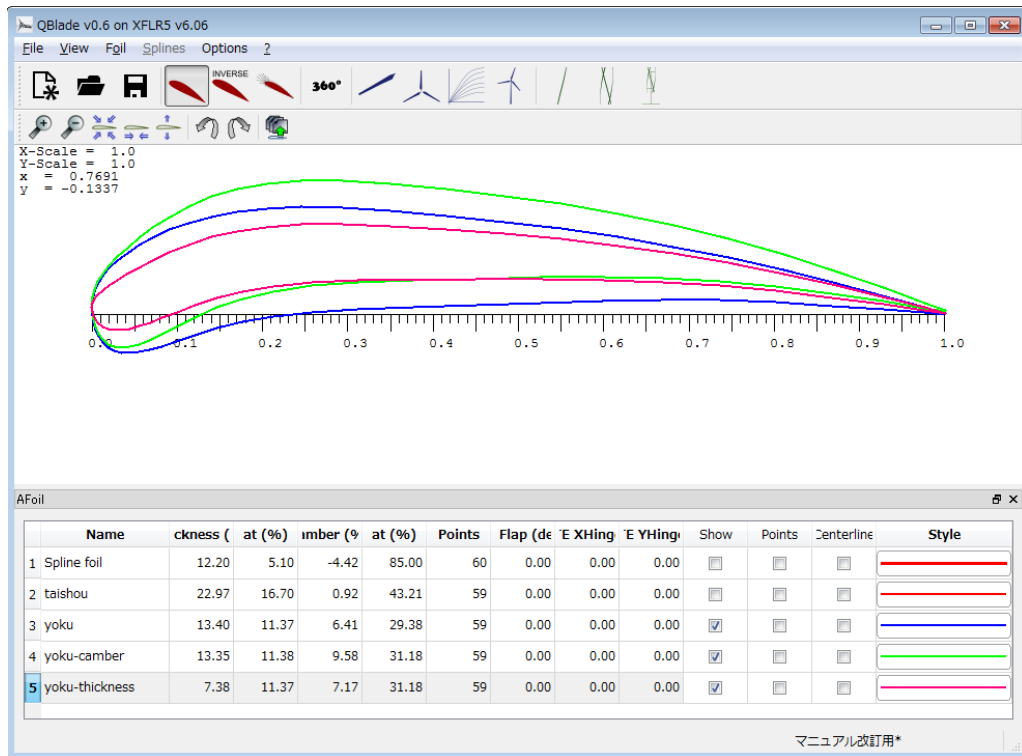
(6) Click Foil → Scale camber → thickness and adjust the Thickness gage. Change the thickness of the blade and click ok.



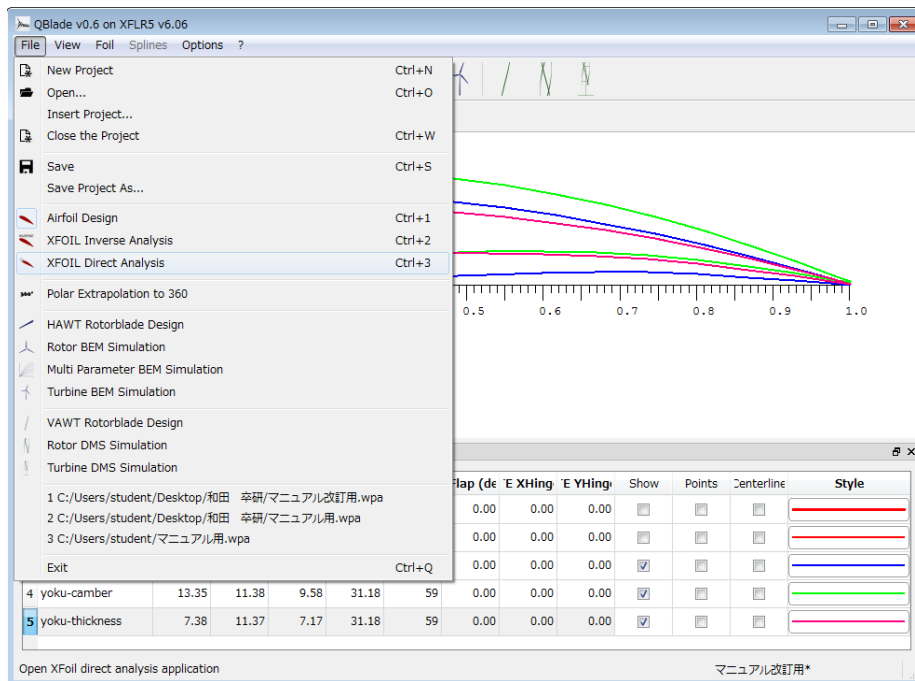
(7) Name the blade and save.(ex. yoku-thickness)



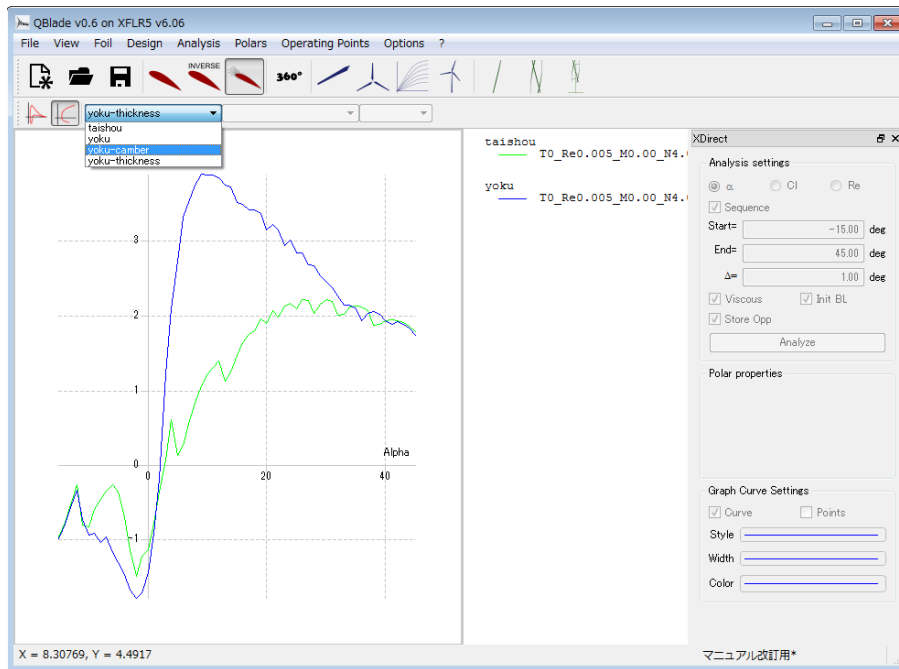
(8) Now you get three kinds of blades.



(9) Click File → X foil Direct Analysis.

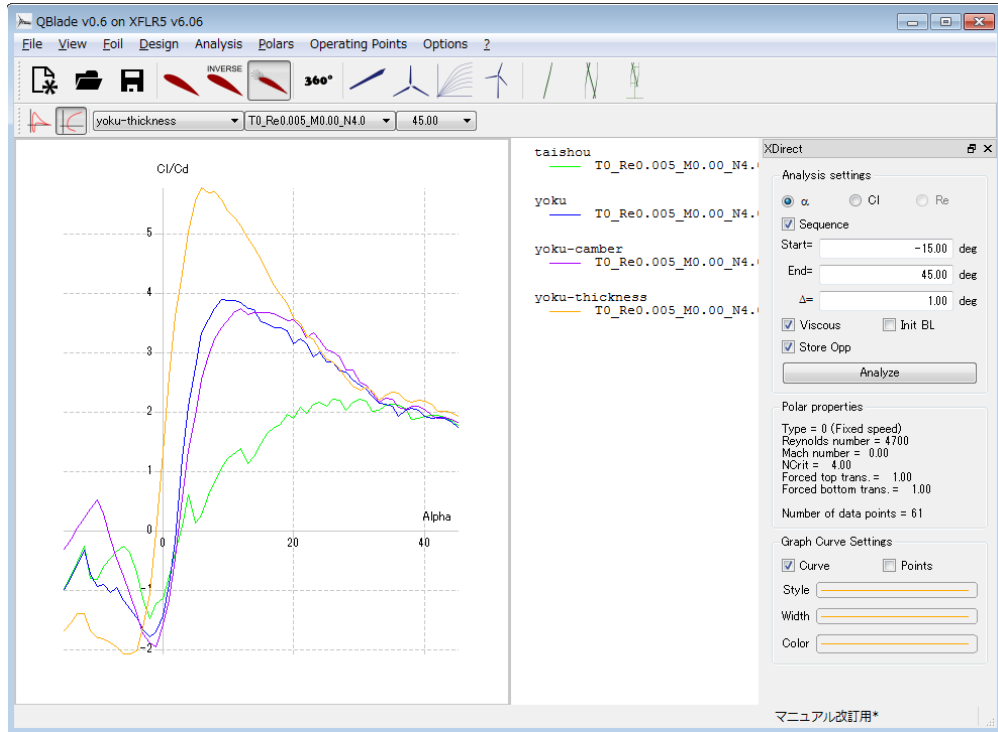


(10) Change from “yoku” to “yoku-camber” .



(11) Do the same as I -5-(18)~(20) for “yoku-camber”, “yoku-thickness” and analyze.

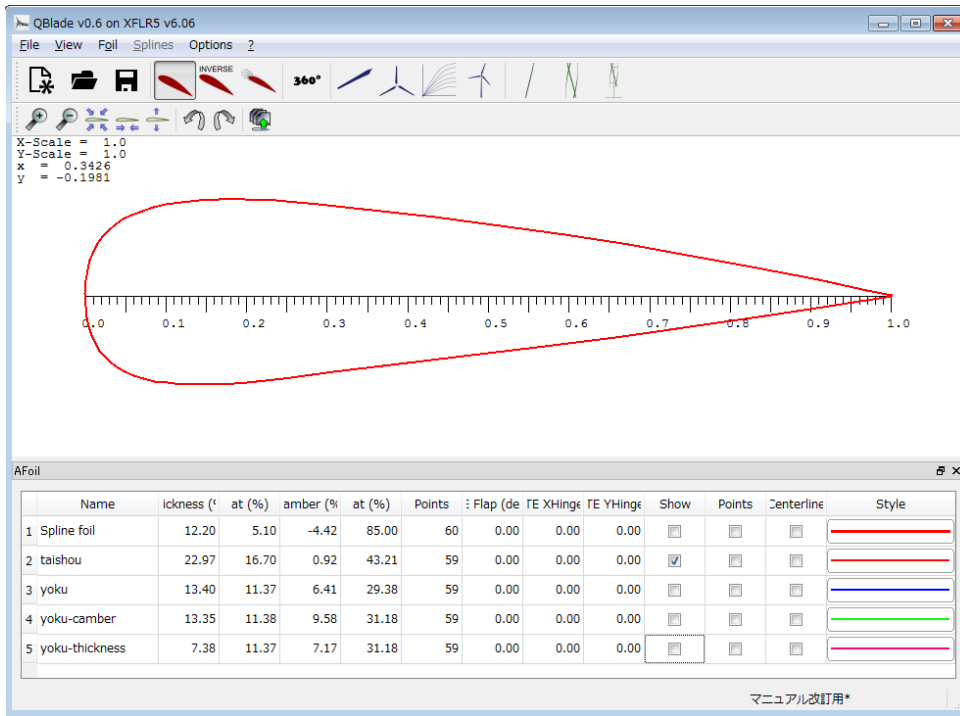
- Type in the Reynold’s number calculated in II -1-(d).



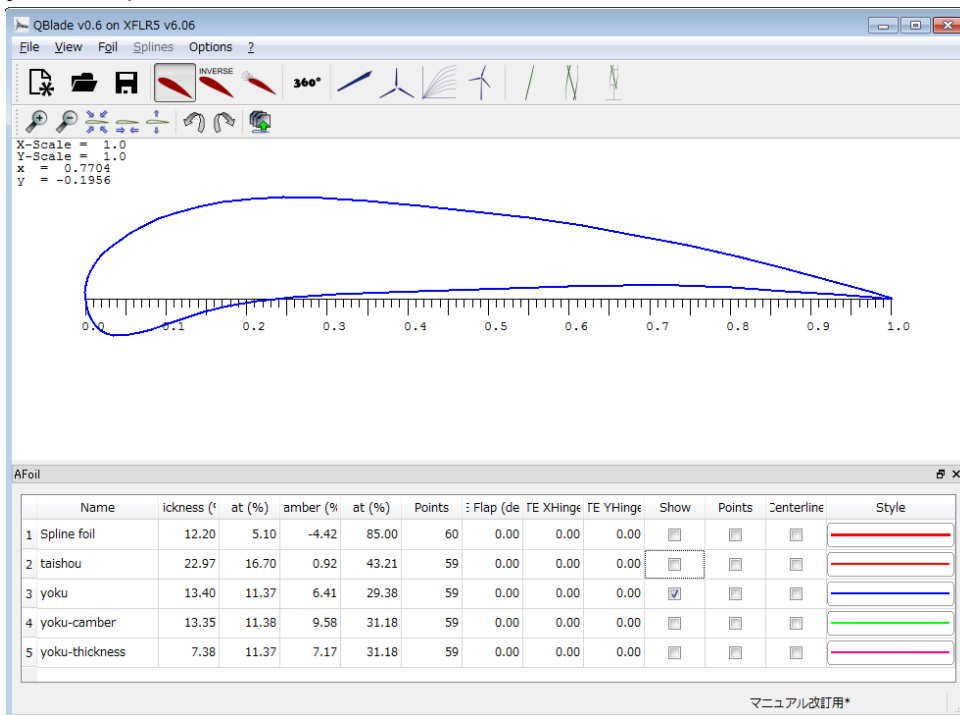


※These are images made in this manual.

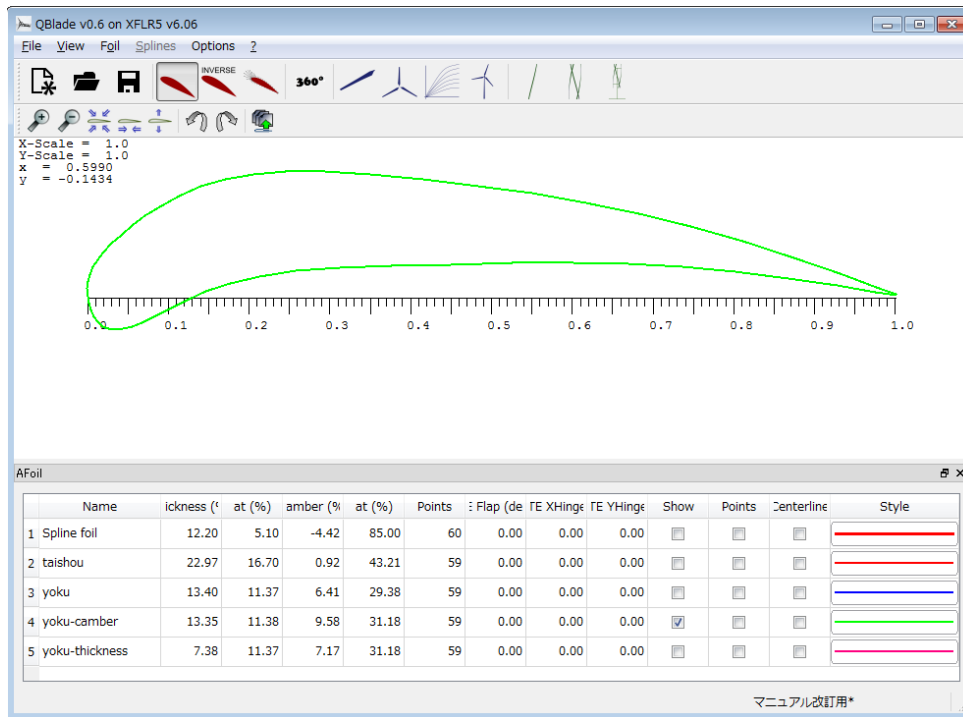
- taishou.bmp



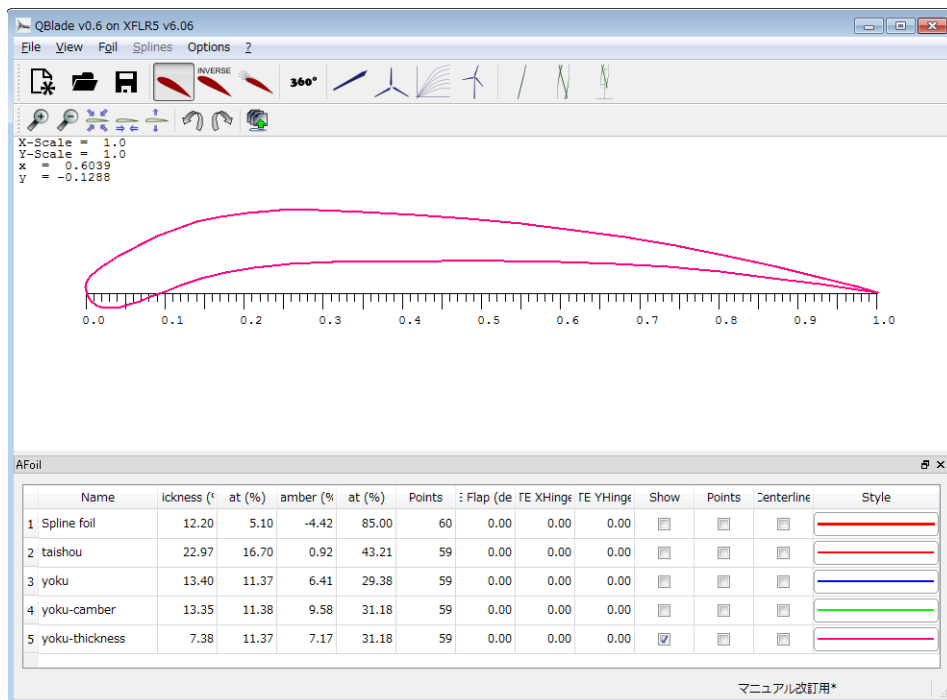
- yoku.bmp



• yoku-camber.bmp



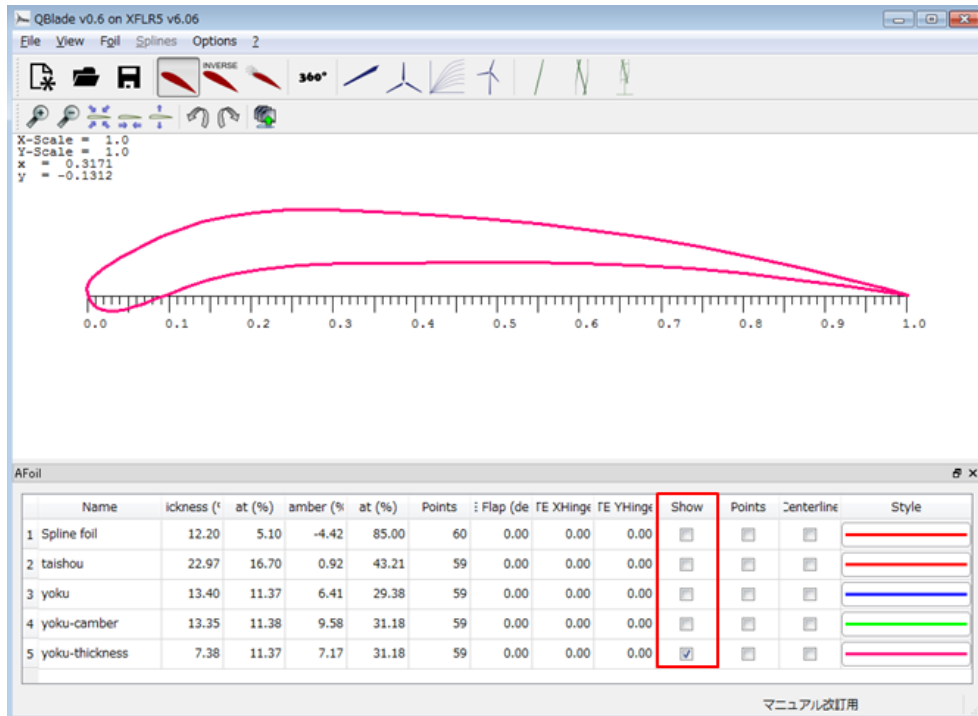
• yoku-thickness.bmp



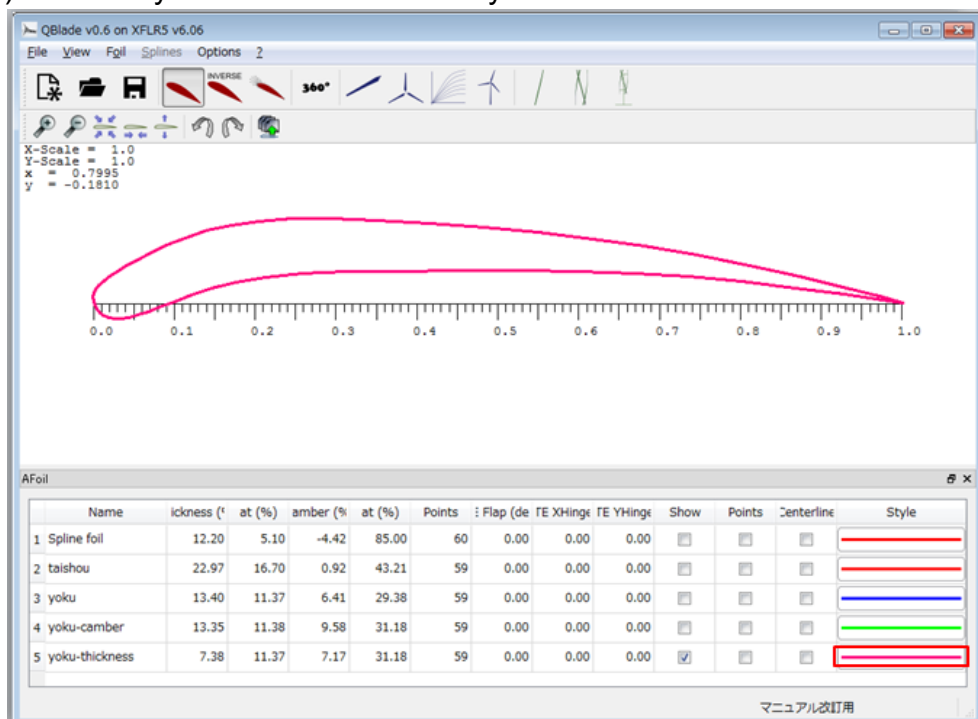
## 2. Considering the best wing form

(1) Save the image

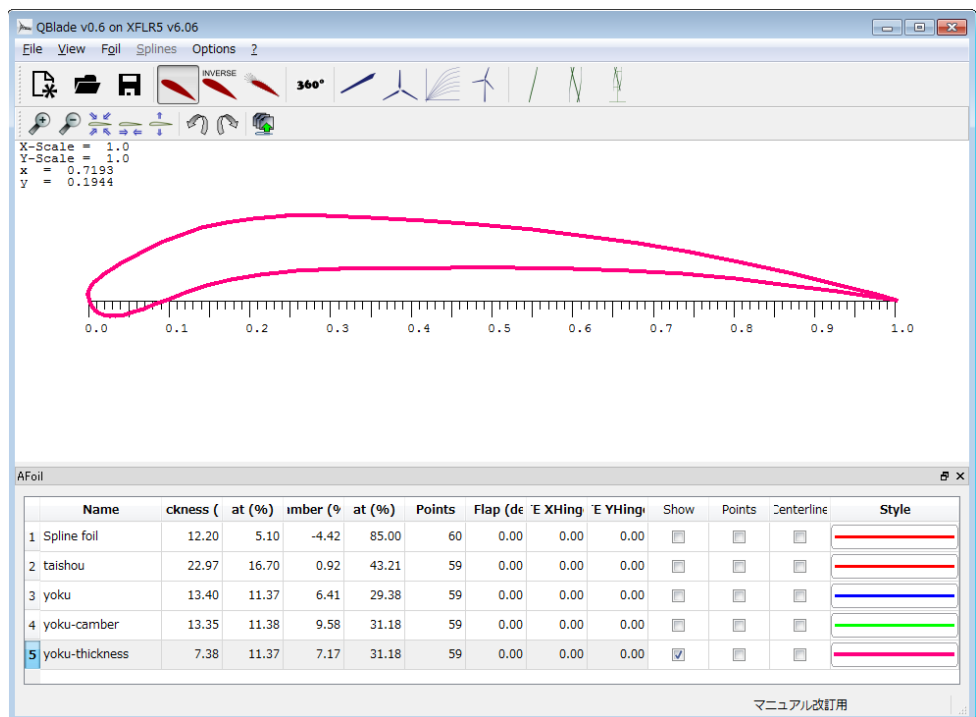
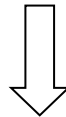
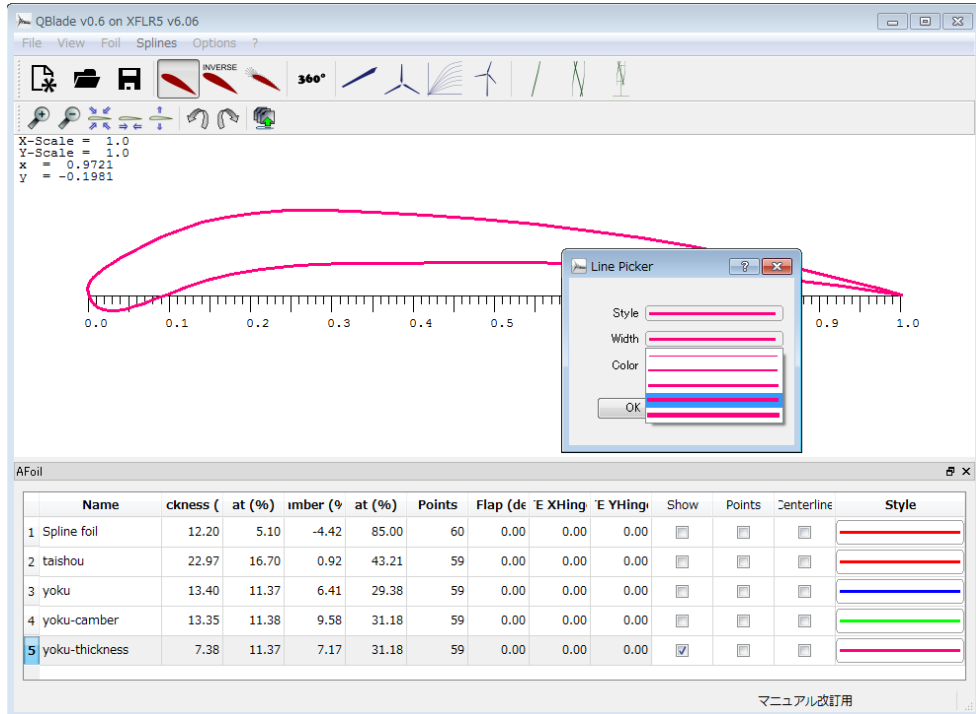
(a) Check only on “yoku-thickness”.



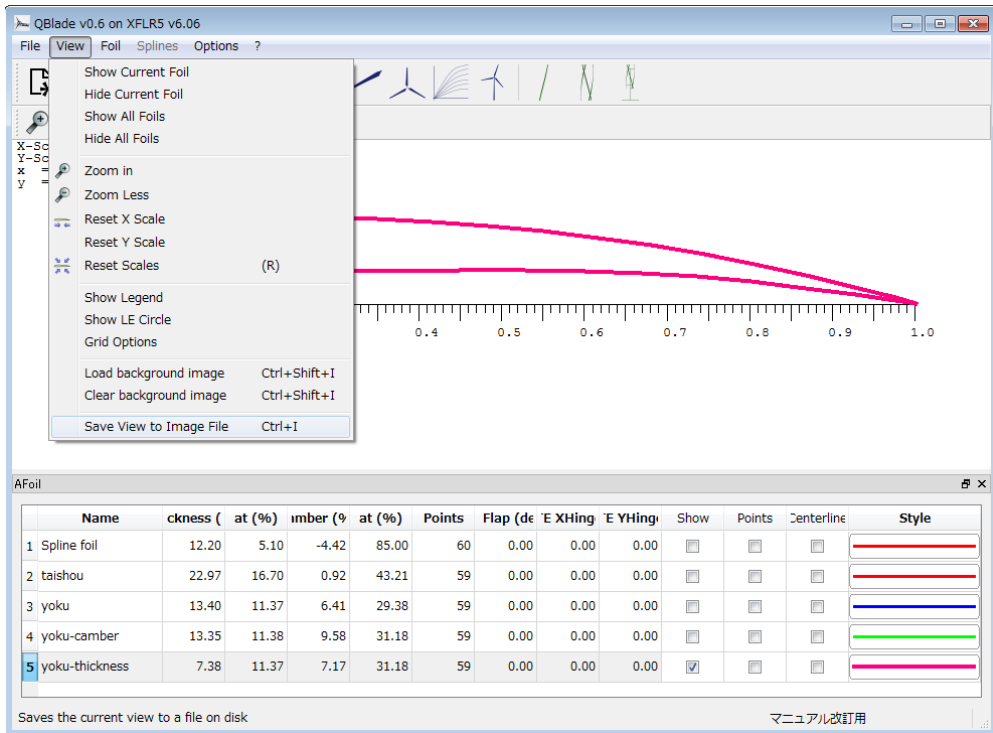
(b) Choose ” yoku-thickness” from Style as shown below.



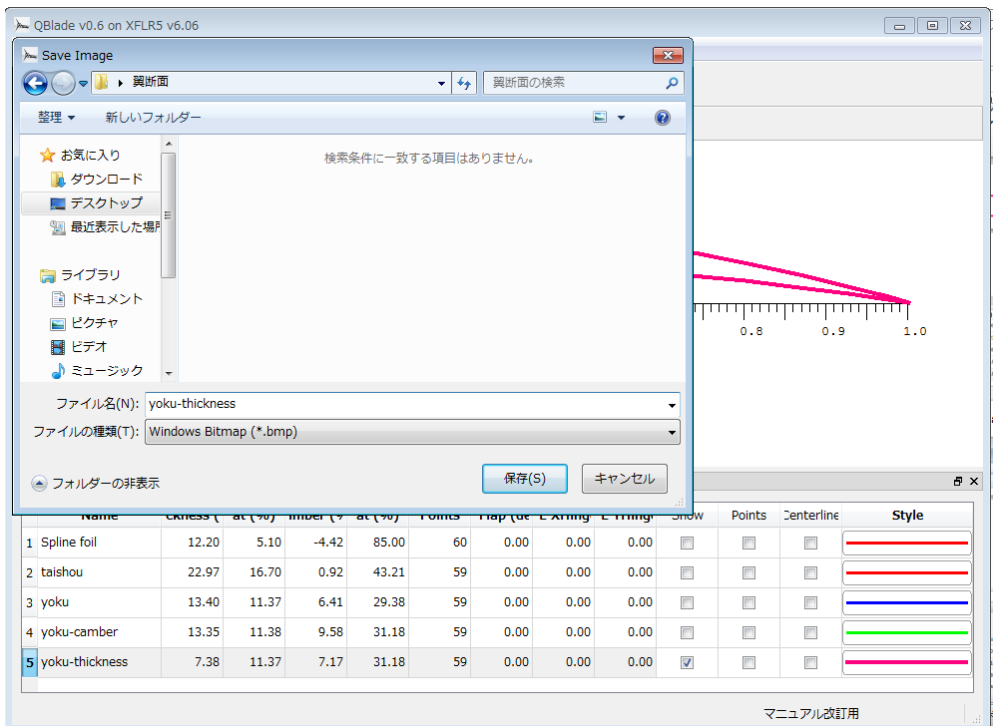
(c) Choose Width and change the width of the line.



(d)Click View → Save View to Image File

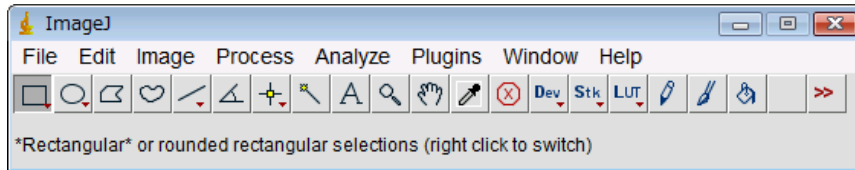


(e)Name the blade and save.(ex : yoku-thickness)

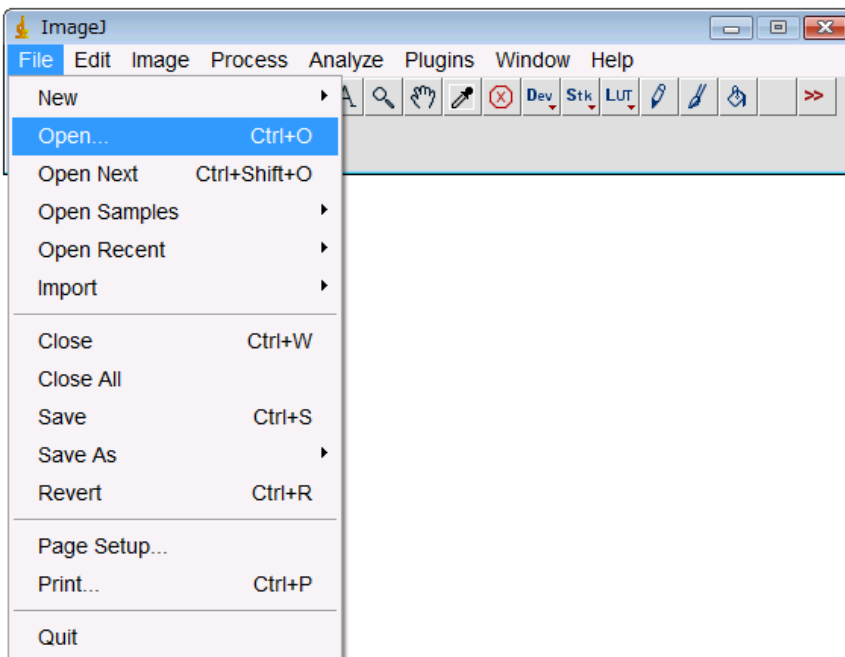


(2) Printing the image

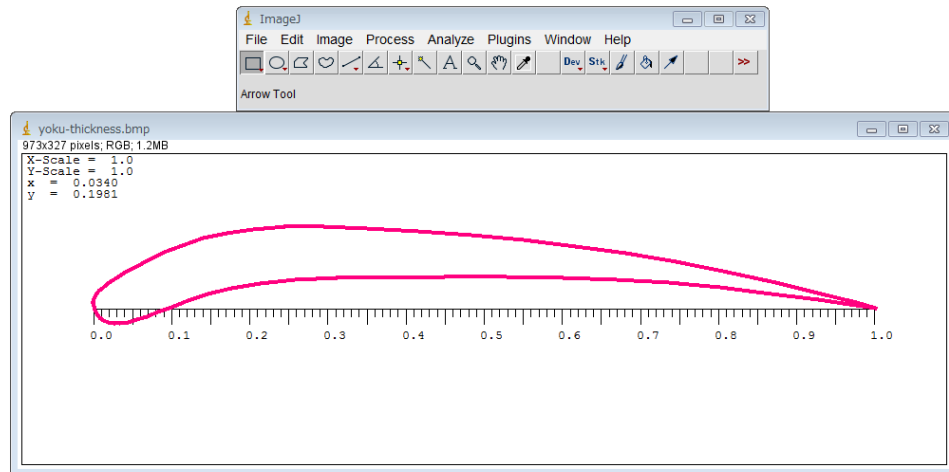
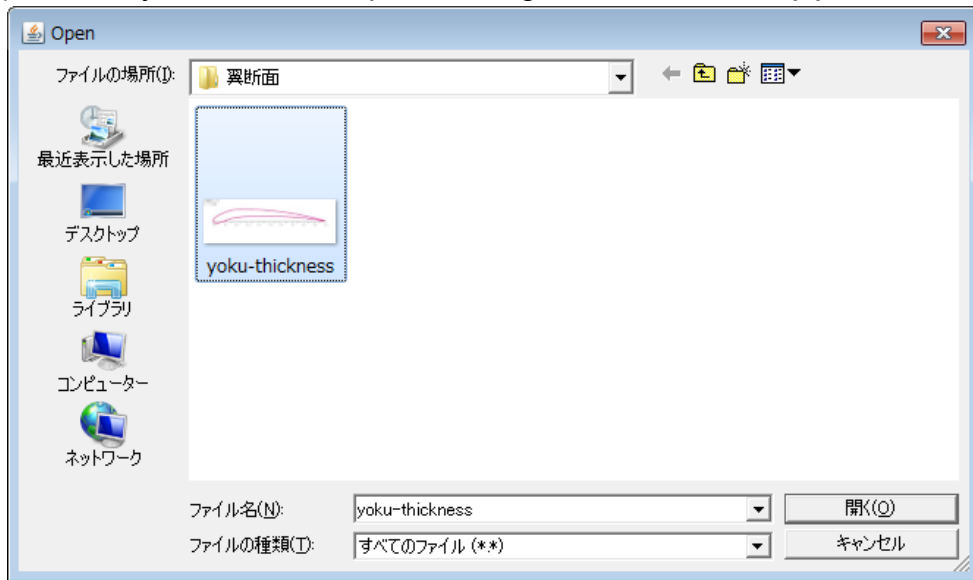
(a) Activate Image J.



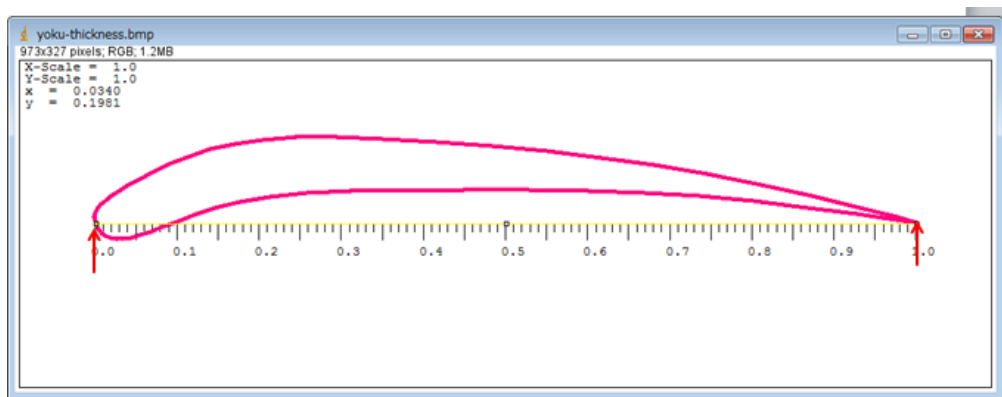
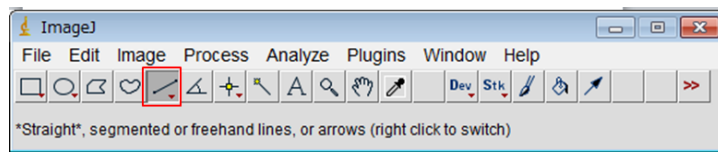
(b) Click File → Open.



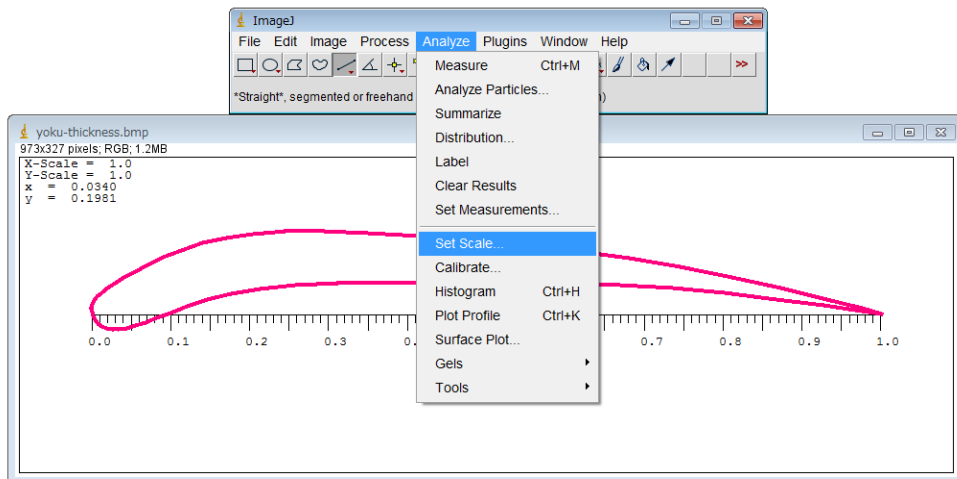
(c) Choose yoku-canber.bmp from images saved in III-1-(1)



(d) Draw a line from the front to the back of the blade using Straight tool.



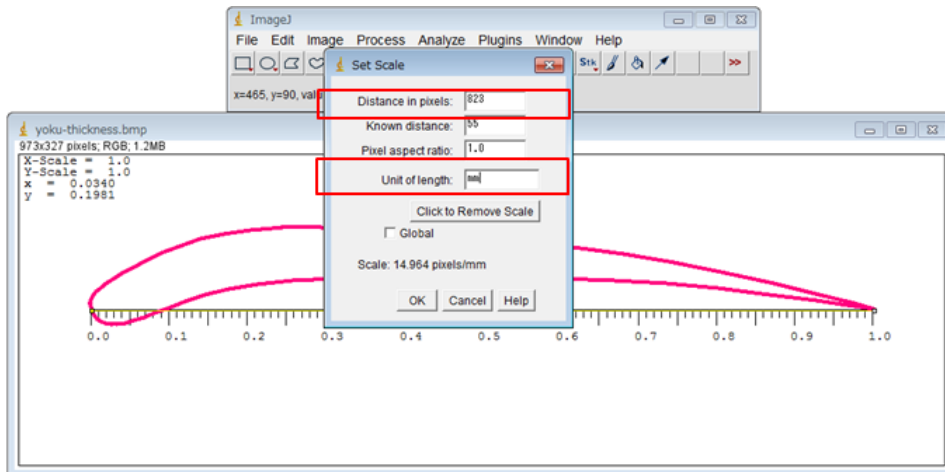
(e) Click Analysis → Set Scale.



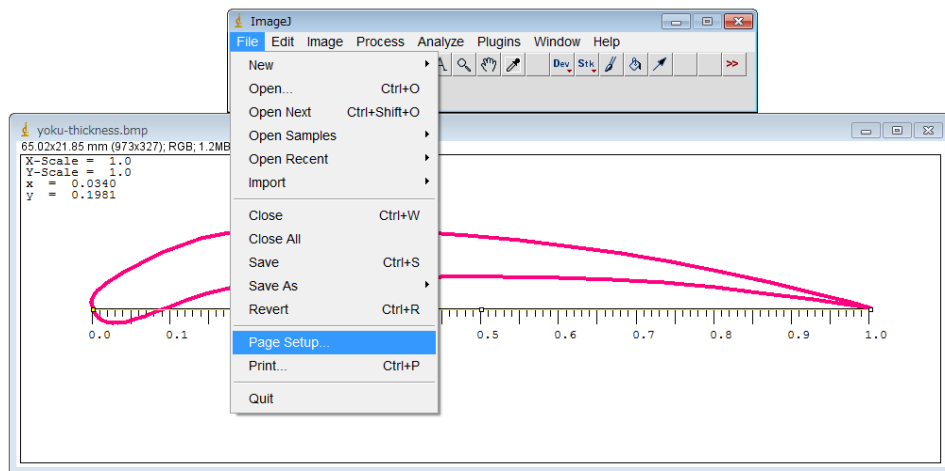
(f) Type in the whole distance of the blade in Known distance and type



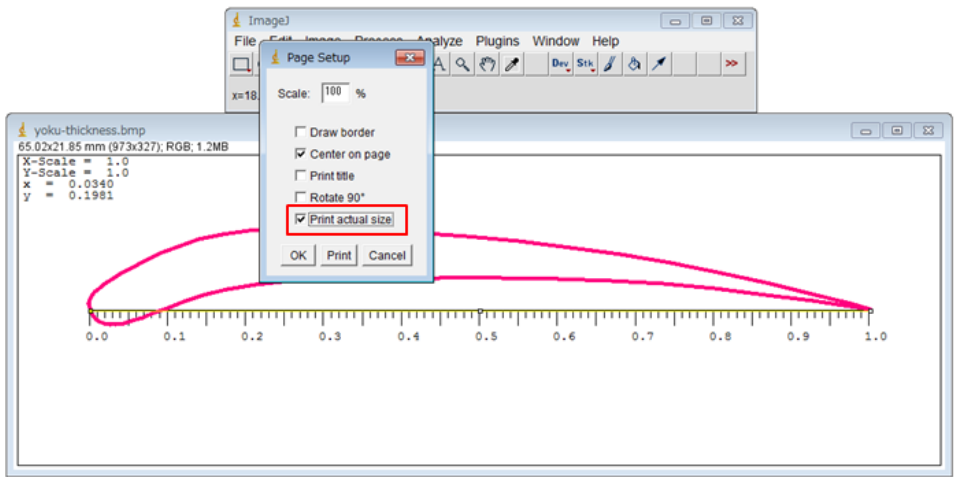
[mm] in Unit of length.



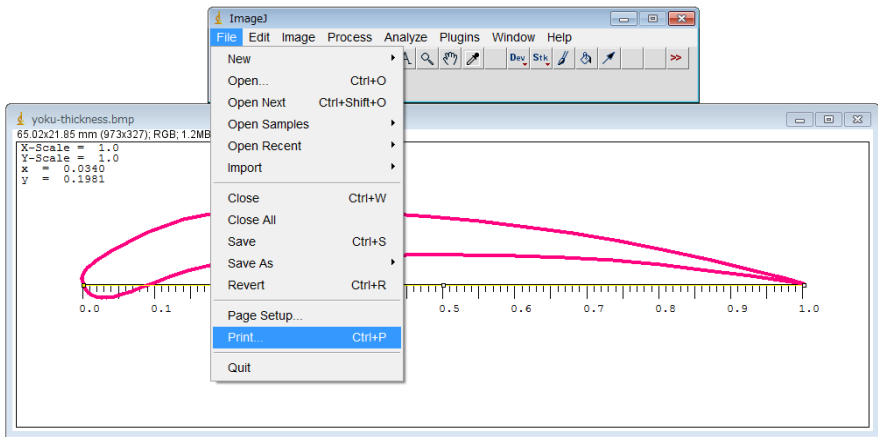
(g) Click File → Page Setup.



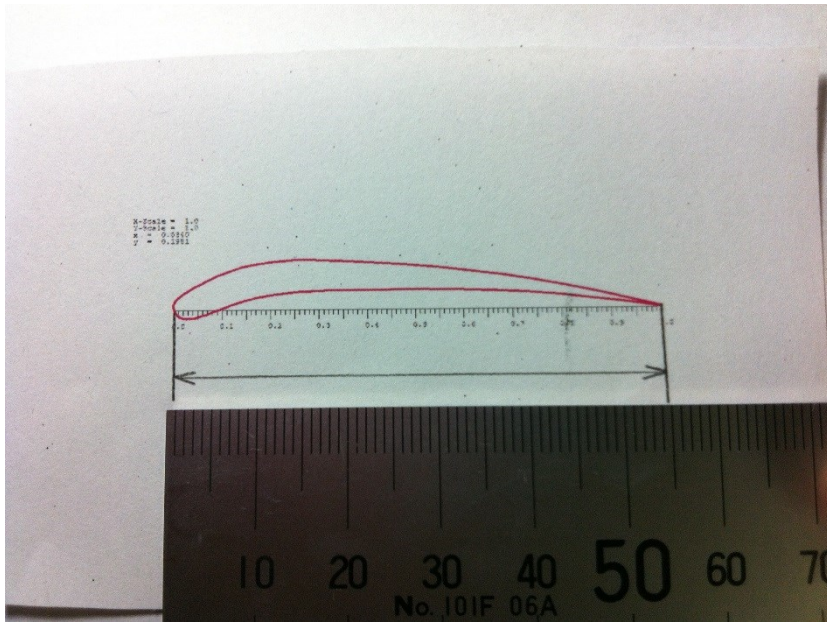
(h) Check Print actual size and click ok.



(i) Check File → Print and click ok.

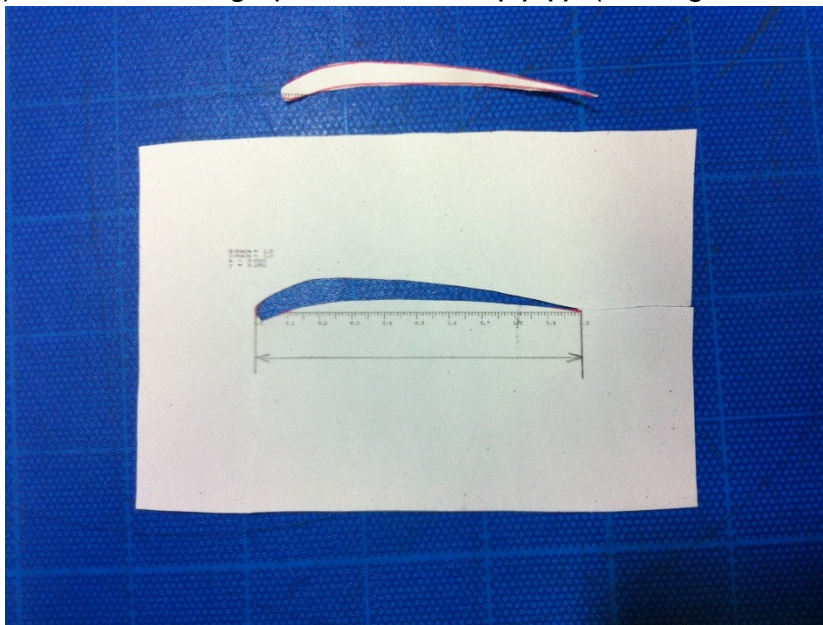


• It will be printed as the same size as selected at **III -2-(2)-(f)**.

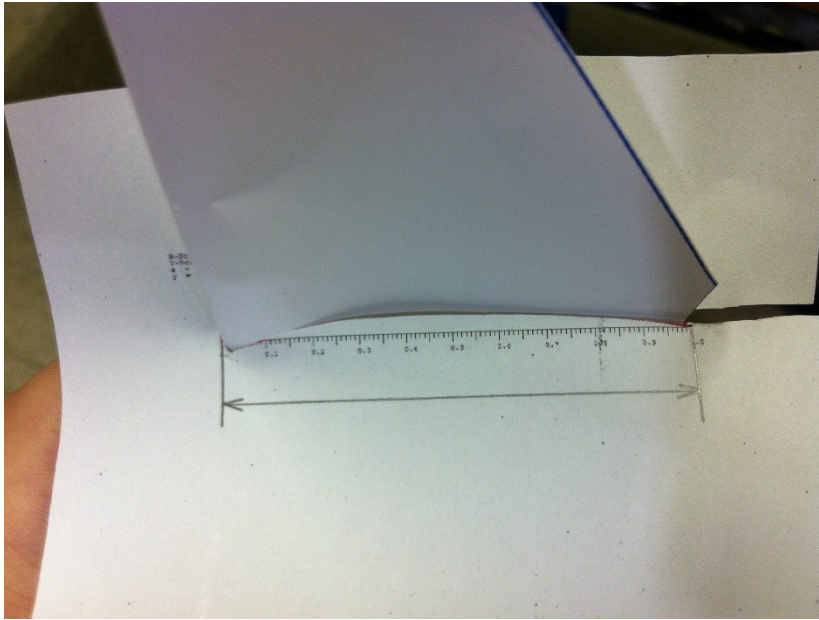


(3) Reforming the blade

(a) Cut out the image printed in **III-2-(2)-(i)**. (making the blade gauge)



(b) Put the blade gauge to the blade and make it fit.



(c) Measure the wind speed, revolution speed as shown in **II -1** and watch closely to the difference.

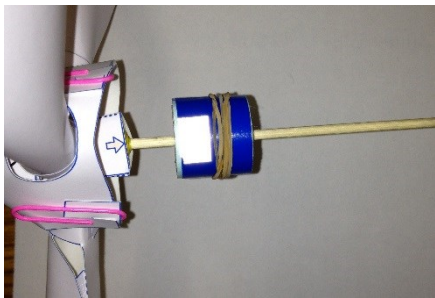
(It might be different from the hypothesis you made depending on other conditions)

## Appendix: Preparation

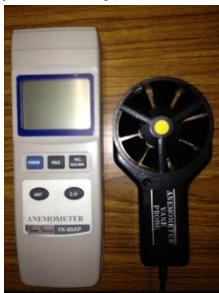
- (1) Paper craft wind turbine
- (2) Fan
- (3) Convex (2m)
- (4) Tachometer



Seal the reflection seal on the axis



- (5) wind speed meter



- (6) Scanner or a digital camera
- (7) Windows PC
- (8) ImageJ
- (9) QBlade
- (10) Spread sheet program