Developables
Developable FreeForm Envelopes

What are they?
Developable surfaces are ruled surfaces, which means that at every point of itself there exists a straight line which remains within the surface. However not all ruled surfaces are developable. These surfaces have a 0 gaussian curvature and can so be mapped on a flat surface (unrollable). In simple words, it is a single curved surface.

So what?
In short, it allows architects to use freeform curved envelopes for their buildings without having to suffer the negative facts of double curved surfaces. The problem with double curved surfaces is that you’re restricted within the choice of materials and you have to resort to expensive technologies in order to “stretch” the material. Single curved surfaces can be easily be obtained by folding a flat sheet of material thanks to an (inexpensive & fast) sheet bender.

Cones and Cylinders are basic developable shapes, they can be obtained by bending a flat sheet of metal.
Is it new? No, not really. The beneficial properties of developable surfaces have been known for a long time in many areas of engineering. Especially in the domain of aeroplane industry it has proven its usefulness. In the architecture we began to use this kind of surfaces since the 50’s thanks to the constant innovations in concrete. However the forms used within the buildings remained simple because the technologies at that time didn’t permit to design more complex forms.

It’s only since the last decade of the past century that the complexity of the projects could evolve thanks to development of computer graphics.

The innovations within concrete (and later-on plastics) from the 50’s-70’s gave architects the possibility to finally move away from the pythagorean geometries we’ve been using since thousands of years in construction. The problem is that it’s really hard to represent and create curved surfaces with a paper and pencil, so we need to make use of digitally driven techniques. The idea is nice but while a computer is able to show a perfectly curved surface on the screen, in real life it’s much harder to obtain such a shape. Single curved surfaces is a compromise between flat surfaces and fully curved ones. You can design complex curved envelopes while remaining almost the simplicity of pythagorean geometries.

What is possible? What is important to notice is that developable free-form envelopes can be subdivided in 2 categories: “Pure Developables”, which are envelopes of which the whole can be considered as a developable form. Formwise you’re limited of the forms you can obtain. And the second one, “Composite Developables”. Which are envelopes which in themselves are not a developable surface but which are composed of developable surfaces.

So it’s cheaper, that’s all? A typical composative developable, every modul in itself is developable.

The easiest way to create developable surfaces is to “loft” 2 freeform rails together. However this will give you just a result, not the result. Between two rails there exist an infinity of developable surfaces. In order to gain control of the loft command “ruling guides” need to be created. I’ve however not been able to find a way of creating them automatically, so it’s a time costing process.

How to create them?

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Paper Folding, a possibility?

Origamis (paper folding) have been practised since more than 400 years. However, only recently people started experimenting with curved folding lines instead of straight ones. This innovation drastically changed the aspect of paper folding. It allows to obtain elegant single curved surfaces. This transition has made it much more difficult to create the origamis. By example it’s almost impossible to obtain the forms only by hand. The folding lines have to be burned by a laser beforehand, and normal paper is often too weak for these forms. Due to these increasing complexities it takes a long research and find a single pattern. This might also be the reason why it’s hardly possible to find any developed pattern to fold on internet.

Algorithmic Modelisation a necessity?

Creating a developable surface isn’t complicated in itself. The simplest way consist of creating two curves and then lofting them together. To gather more control of the surface guiding lines can be used. Nothing more simple. Things get complicated when you want to manipulate these developable surfaces or trying to work further with the properties of the surface, in order to find new forms. Thanks to plugins, like Grasshopper or Rhinoceros, we’re able to work with the properties of developable surfaces, instead of just creating them. This allows us to gain access to more complex forms.

Thanks to Grasshopper, I was able to change the width of the surface based on the intensity of the bend at a local point, creating a shape fully based on the surface properties.

It’s by example also possible to change the depth of a volume based on the intensity of the curvature.

Mixing both diagrams together can create interesting forms. In this case it remains simple, because both curves are identical.

On the right another example of curved paper folding found on internet. On the left a personal test of paper folding, with straight folding edges, even with this kind of model it can be very tough to create the origami without the appropriated experience.
Frank O. Gehry

Who is he? Frank O. Gehry is an architect known for his buildings based on deconstructivism. This new architecture style mainly focuses its interest on the envelope form, which often seem unpredictable. He was one of the pioneer using computerized techniques with Dennis Shelden.

The shape of this building can be obtained by lofting two different curves together. Because of the fact that it's a curved surface it can be unrolled.

First attempt of understanding

Guiding Lines

Thanks to guiding lines we gain more control of the lofted surface. The examples on the left side show multiple alternatifs of Der Neue Zollhof. These four surfaces have been created thanks to a Grasshopper diagram which automates the process.
Frank O. Gehry, Walt Disney Concert Hall
1987-2003

Front Entrance Perspective

70 Curves, guiding the surfaces

All Surfaces the unrolled

Unrolled surfaces of the front envelope
How to translate it in models?

Different types of models using developable surfaces

Paper Folding might also be a solution but creating a folding pattern is more difficult then it looks

Like developable surface possesses a straight line within itself at every point, It might be a good opportunity to work with this property within making models itself, and expressing the ideas.

Sources

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